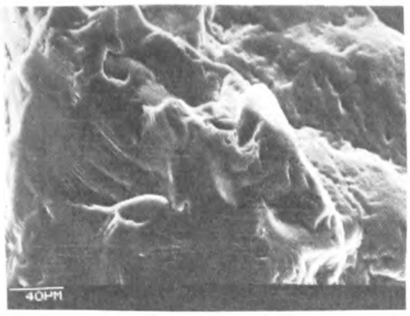
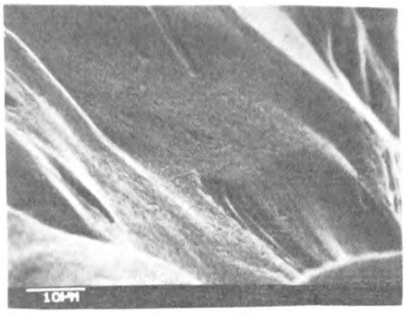
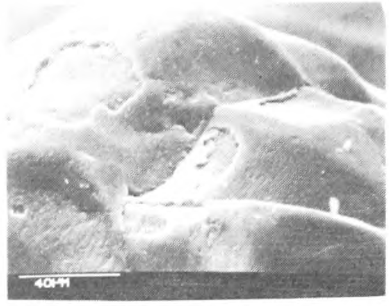
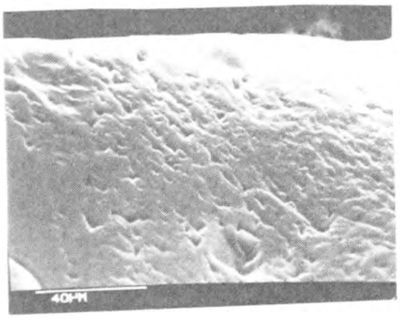
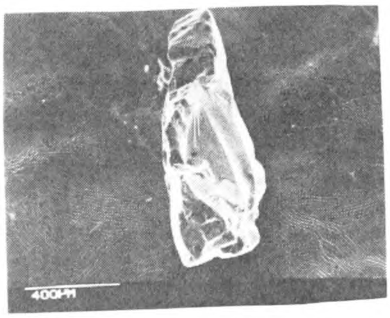
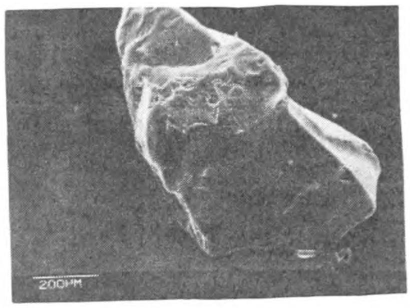




ENVIRONMENTAL DISCRIMINATION OF BARRIER ISLAND SEDIMENTS BY S.E.M.

M.C. THOMAS

Thesis presented to the C.N.A.A., for the degree of Master of Philosophy, Department of Science, The Polytechnic of Wales, PONTYPRIDD, M Glam, in collaboration with the University of Maryland, College Park, MARYLAND, U.S.A.

May 1986

CERTIFICATION OF RESEARCH

This is to certify that except where specific reference is made, the work described in this thesis is the result of the candidate. Neither this thesis nor any part of it has been presented or is currently submitted in candidature for any degree at any other university or polytechnic.

Signed...M. C. Thomas...........

(Candidate)

Signed...............................

(Director of Studies)

Date............2 May 1986..........

Acknowledgements

I would like to gratefully thank Dr. A.T. Williams for all his assistance, hard work and faith in this thesis.

I would also like to thank my typist, Linda Thomas for all her help and Oscar Williams for his fortitude in the face of adversity.

Abstract

Environmental discrimination was undertaken on five Barrier Island samples, representing overwash, inlet, flood tidal delta, aeolian and beach environments. S.E.M. textural analysis, utilizing a checklist of thirty-six common surface features, coupled with photographic evidence was used to analyse the nearshore samples. Checklist results in the form of binary data, were subjected to discriminant analysis.

Checklist results were unable to discriminate between samples, which revealed a glacio-marine type texture pattern. Longshore drift eroded glacially derived quartz grains, marine processes then superimposed a new textural suite to create a glacio-marine textural assemblage. Three phases of superimposition are tentatively proposed:

(a) Mechanical abrasion.

(b) Chemical solution/precipitation.

(c) Secondary mechanical phase.

Discriminant analysis was unable to distinguish between the Five nearshore samples but was able to discriminate between the nearshore samples and two control samples (Kalahari Desert and Brazilian crushed quartz). Two-group analysis was also performed and indicated generic linkage between nearshore samples, particularly overwash and dune sediments.

Environmental discrimination was not possible by one method alone, a combination of qualitative and quantitative methods was needed. Two grain types were indicated in both onshore and offshore samples and a bi-modal provenance is proposed for these samples (see Inlet plate 1,2, 3, 4).

In conclusion it was possible to identify large scale textural development but more subtle discrimination between nearshore samples was not possible.

<u>Appendix</u>

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CHAPTER I

CHAPTER I

I (i) Introduction

Microtextural analysis of sand grain surfaces has been regarded as an important indicator of the environment through which a sediment has passed (Bull, 1981). Until the advent of the electron microscope it was not possible to examine grain surfaces in detail but subsequent development of the Transmission Electron Microscope and more importantly Scanning Electron Microscopy enabled high resolution microscopsy studies to evolve. The popularity of the technique lies in its ability to identify the sequential passage of sediments through environments of modification, a supersition which forms the basic dictum underpinning this work.

A number of environments are comprised of characteristic energy conditions which, given necessary time, interact, modifying the sediment within that system. This can take the form of mechanical abrasion, chemical precipitation or solution. Energy conditions within any one environment may be discrete, resulting in a surface texture assemblage indicative of that general environment. Supersition of assemblages is then possible, resulting in a new textural suite upon the sand grain surface. The end result being a palimsest surface. This premise is well illustrated in Inlet plate 15, a grain with a multiplicity of chemical and mechanical episodes, superimposed on its surface.

Discrete sets of textures are normally simple to identify since environments of modification are normally very different. Glacial erosion and transportation involves little or no water action, so crushed grain surfaces will lack water rounding. Aeolian transportation by saltation in arid conditions produces a number of chemical and mechanical features quite distinctive from those produced in other environments. Textures characteristic of glacial environments include high relief, semiparallel steps, breakage blocks. Littoral beach textures include mechanical V's, blocky conchoidal breakage patterns. (Krinsley and Donahue, 1968)

The use of textural analysis, either independently or part of a wider sedimentological study, is traced in the literature survey (Chapter 4). Rapid growth since 1968 in environmental reconstruction from S.E.M. analysis of quartz sand grains has not been without its problems. Number of grains used for analysis is acknowledged to be important statistically yet the number tac itly accepted ranges from 10 - 300 grains and it still a matter of debate. Grain texture identification and evaluation of surface area development, coupled with the relative isolation of individual electron microscopists are other problem areas. The literature also reveals a number of methodologies in use, although later papers (Cater, 1984; Bull, 1981) have used the checklist approach, as an initial analysis extraction method and answers an earlier call from Margolis and Krinsley (1971) who stated that the technique had advanced beyond presenting individual photographs as evidence of the history of a grain and now involves a more quantitative treatment of data.

For this study a more quantitative treatment of data will involve detailed investigation utilising multivariate statistical analysis techniques. How far can the statistical model fit raw textural data? This is a continuation of work first touched upon by Bull (1981). Several methods will be compared to assess their viability and reliability for this type of work. The use of a checklist (in binary form), does have certain inherent problems (Press and Wilson, 1978), but it is hoped to show that multivariate analysis can become a tool in reconstruction studies especially where unique and heterogenous environments are analysed. Whether differentiation can be achieved when environments are genetically related (as in the nearshore) is open to question!

The diversity of the subject has enabled reconstruction to be attempted in most areas of the world. Little, if no analysis has been undertaken on barrier island sediments possibly as a result of the supposed interconnectedness between environments. Implicite within the analysis is an understanding of the dominant geomorphic process in each environment, essential to correct interpretation of textural data.

The Barrier Islands of Long Island, are dynamic, relatively low land masses composed of a complete system of beach, dunes, marshes, and flats. Each of these geomorphic elements has a characteristic shape, resulting from distinctive or combination of processes, dominated by the marine environment. The physical characteristics of the water, affect all aspects of the Barrier environment, creating five main sand moving processes:

(a) Littoral drift
(b) Onshore Bottom Currents
(c) Wind
(d) Overwash
(e) Inlet formation

It is postulated that each of these processes, because of their unique associated energy conditions has imparted distinctive suites of features on the grain surfaces, allowing discrimination between the various nearshore environments. Do the processes exert similar or disproportunate control upon sediment deposition and is this reflected in the sediment history?

This investigation is part of a larger sedimentological study, in conjection with the work of Leatherman (1985), Williams and Scott (1985) and Williams et al (1985). Five environments were sampled:

(1) Flood Tidal Delta (F.T.D.)
(2) Beach
(3) Inlet
(4) Dune
(5) Overwash

Two control samples, Kalahari Desert and Brazilian crushed quartz were subsequently added.

Environmental history reconstruction was made utilizing photographic and checklist analysis coupled with previous workers' results, notably Margolis and Krinsley (1971), particularly where discrimination used mechanically produced textures and related morphologies such as relief, roundness, etc. Features originating from chemical precipitation and solution are common, but are notoriously bad environmental indicators (Margolis and Krinsley, 1971).

CHAPTER 2

CHAPTER 2

Physical Background of the Long Island South Barrier Chain

(2) i Location

Long Island is a narrow elongated island, situated to the Northernside of the New York Bight, in the Atlantic Coastal Plain province of the United States of America. (Fig. 2.1)

The Island trends E - N.E. and is divided into the Easternmost 33 miles from Montauk Point to Southampton. (The headland section) (Fig.2.2) and the remaining 87 miles stretching from Southampton to Coney Island, containing the Barrier Island Complex. The complex consists of four Barrier Islands - Fire Island, Jones Beach Island, Long Beach and Coney Island. In a landward direction, there are a series of inter-connected tidal lagoons, comprising Shinnecock, Moriches and Great South Bay, separating the barriers from the mainland.

(2) ii Geology

Geologically, little is known about the pre-Cambrian and early Palaeozoic history of Long Island. Fuller (1914) suggested that the area was submerged until deposition of the red beds in the Triassic but no record of this is found. Elevation and subsequent erosion of the area during Jurassic times is believed to have formed a featureless basement complex. The Cretaceous period was one of tectonic instability, which created successive cycles of marine transgression and regression, coupled with widespread periodic warping and sinking, resulting in deposition of the Magothy clays, which are overlain by the Monmouth sediments, deposited in a shallow shelf environment during a transgressive period (Perlmelter and Todd, 1965). After the Cretaceous period, there was widespread regression, allowing the Long Island surface to be eroded.

The present day topography and underlying sediments are the product, indirectly or directly of Pleistocene Icesheets. Morainal and outwash material associated with glacial and interglacial period represent the majority of surface features. It was hoped that this glacial component was evident in the surface textural analysis of the grains (see Chapter 5).

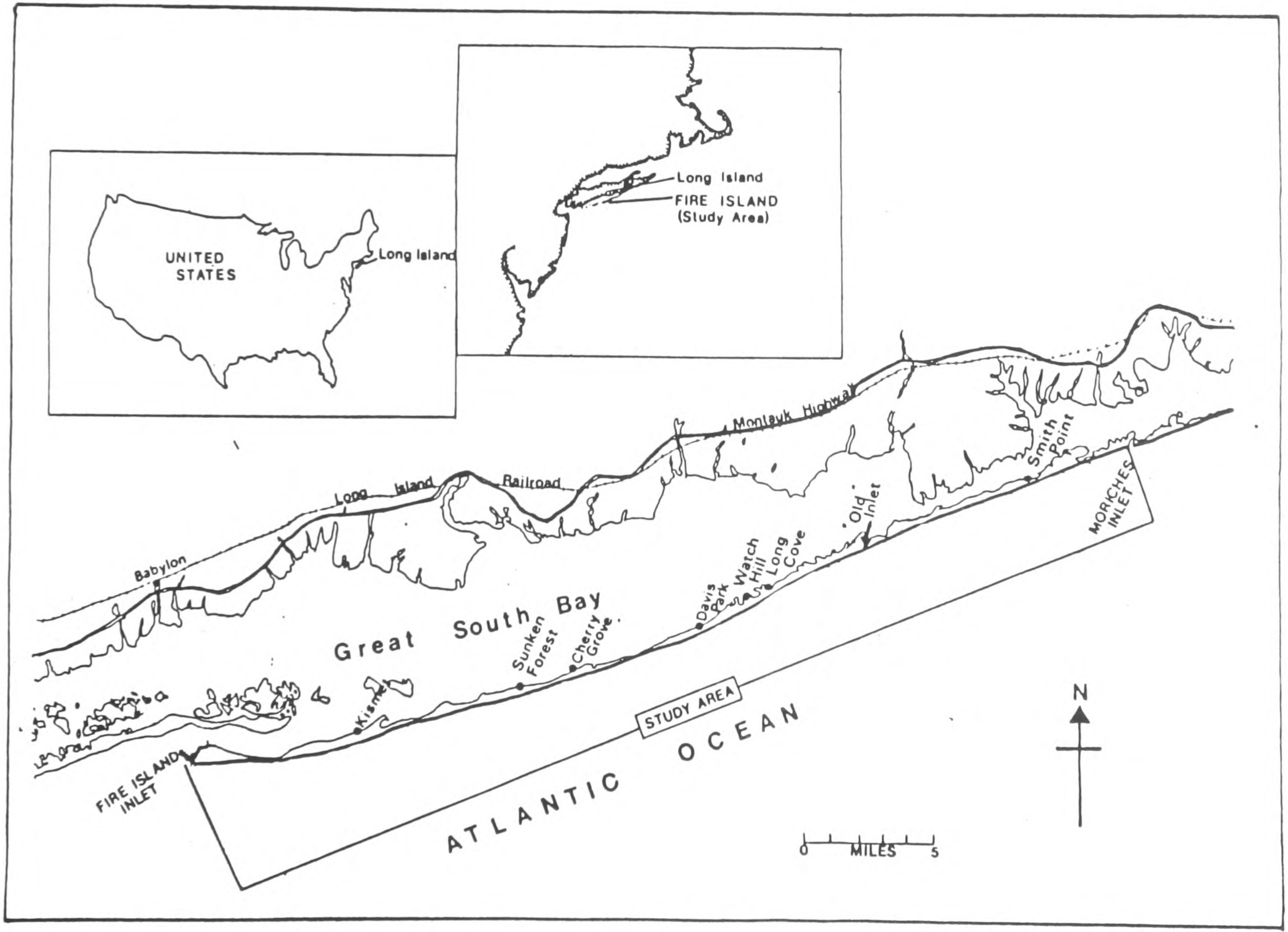


Fig.21 - MAP SHOWING THE LOCATION OF THE STUDY AREA

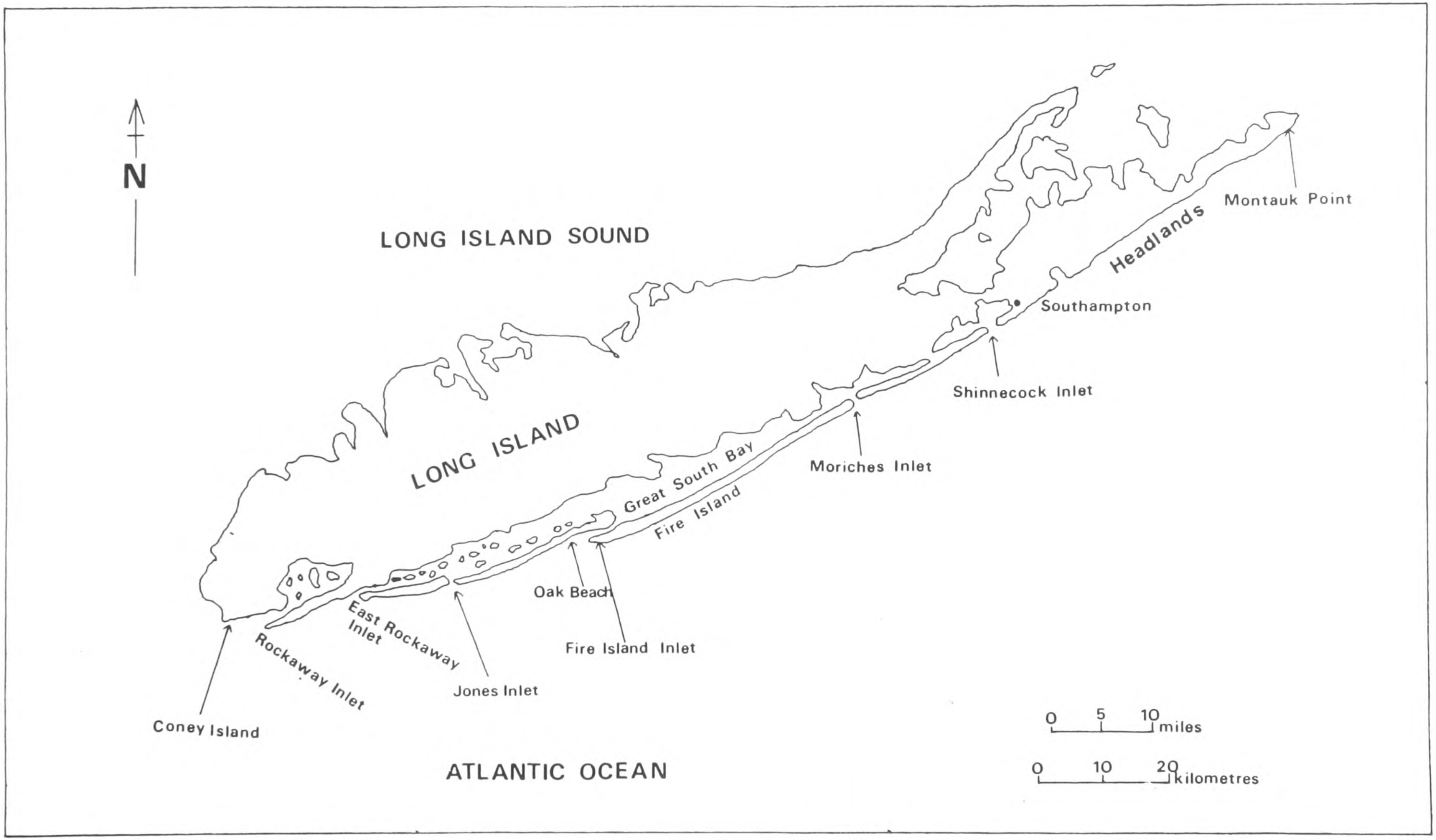


Fig. 2.2 - MAP OF LONG ISLAND SHOWING THE LOCATION OF THE BARRIER ISLANDS ALONG THE SOUTH SHORE (AFTER ASH 1974).

It has been suggested that the ice sheets advanced four times, separated by warmer inter-glacial periods (Fuller 1914). Rampino (1979) and Suter et al (1949) favoured a greater number of advance/retreat phases. Sirkin (1971) proposed that continental glaciers advanced on Long Island twice in Winsconsin time and once in the Illinoian. During the last two advances, the ice front was located on the Island itself, depositing large amounts of glacial debris, mostly gravel, sand and silts, in the form of outwash plains and fans. The glaciers left two sub-parallel moraines. The Ronkonkoma and Harbour Hill moraines, dominate the present day surface of the Island, rising to 100' - 150', reaching a maximum height of 410' above sea level. The Winsconsin moraines are separate entities in the central and eastern parts of the Island and merge together in the west. The older Ronkonkoma moraine extends east to form the south fork of Long Island, while the Harbour Hill moraine extends west to form the north fork becoming submerged at Orient Point (Rampino, 1979). These two major ridges represent the southern termini of glacial advances. As the ice permanently ablated (approximately 1800 B.P.) large amounts of meltwater carried much of the material from the existing moraines, to the south, forming an outwash plain of sands and gravels. At this time the inter-connected system of barrier beaches, islands, dunes, spits, bays and inlets did not yet exist on the south shore. Long Island at this time was probably a simple island with low relief headlands and bays along the south shore.

In the last 10,000 years, during the Holocene period, transgressive deposition has taken place, as a result of deglaciation with subsequent sea level rise, causing the coastline to migrate 50km landwards. Stratigraphic relationships of these deposits with the late Pleistocene, suggest that a barrier island with back lagoon, existed in the area of present day Long Island.

The coastal sediments in this particular area show a vertical and horizontal sequence produced by the movement of successive depositional environments, landward and upward during the Flandrian transgression. Rampino and Sanders (1977) produced the following transgressive sequence for Long Island, from land to sea.

(1) Submerged Pleistocene platform
(2) Fringe of brackish to freshwater marsh
(3) Lagoonal salt marsh
(4) Open lagoonal silty clays
(5) Back Barrier tidal delta and washover sand lobes
(6) Back Barrier fringe salt marshes
(7) Barrier Island, dune sands, beach ridge, beach berm and inlet fill origin
(8) Shoreface sands
(9) Shallow inner shelf sands.

Leatherman (1981) commenting on their findings, concluded that while Barrier retreat rate is dependent upon the balance between sediment supply and sea level change, continuous migration, as opposed to barrier over-stepping, is favoured for low coastal plain barriers and although barrier drowning and subsequent surf zone skipping are theoretically possible, evidence from the New York shelf is not convincing.

Since their formation, the barriers have undergone continued modification from present day forces operating at the land interface.

(2) iii Origins

Most of the east coast barrier islands are probably perpetuated by five main sand moving processes (Leatherman, 1981).

(a) Littoral drift
(b) Onshore bottom currents
(c) Wind
(d) Overwash
(e) Inlet formation

All the above processes are essential to the Island in maintaining a dynamic equilibrium, with changing sea level and the natural forces that continually reshape the coastlines.

Geomorphic and historical evidence reveal that most U.S.A. barriers are currently experiencing seaside erosion and landward shoreline retreat which in turn creates a sea level rise (Hicks, 1972; Emery, 1980).

Traditional theory argues that the barrier response to this sea level rise is landward and upward migration through time (Kraft, 1971; Leatherman, 1979) but Dolan et al (1973) have argued that overwash is the primary process of landward migration during a phase of sea level rise. Recently the predominant role of inlets in landward sediment transfer has been forwarded. Quantitative studies have revealed that many barriers are actually eroding on both sides and experiencing bayside submergence, (Jarret, 1981) while it has been shown for Fire Island, that barriers need not continuously migrate landward. Leatherman and Williams (1982 - P.172) stated "that landward migration is a time averaged phenomenon due to sporadic and site specific storm generated events over the long term" and argued that a barrier may erode from both sides, narrowing through time, rather than migrating landward. For this situation migration is dominated by periodic inlet breaching, in a discontinuous step like fashion. Inlets are temporary features that form in response to barrier island breaching by severe storm tides and are therefore imported as geomorphic agents.

The studies of barrier islands has led to a great debate regarding their origin, growth and migration, with several contrasting models proposed for barrier formation and origin.

The three major theories advanced to account for the initial formation of barriers are:

(1) The upward growth of marine bars.

(2) Segmentation of long coastwide-prograding spits by tidal inlets.

(3) Submergence of coastal beach ridges by a rising sea.

Johnson (1919) following work on the south shore of Long Island accepted the hypothesis of submarine bar upgrowth, first proposed by De Beaumont (1845), determining the following processes in barrier island formation on emergent shorelines:

(1) Large waves break out at sea.

(2) Smaller waves reach the land and erode the coast. Landward erosion proceeds by the action of smaller waves and a wave-cut terrace is formed.

(3) The large waves erode and the wave-cut terrace migrates landward.

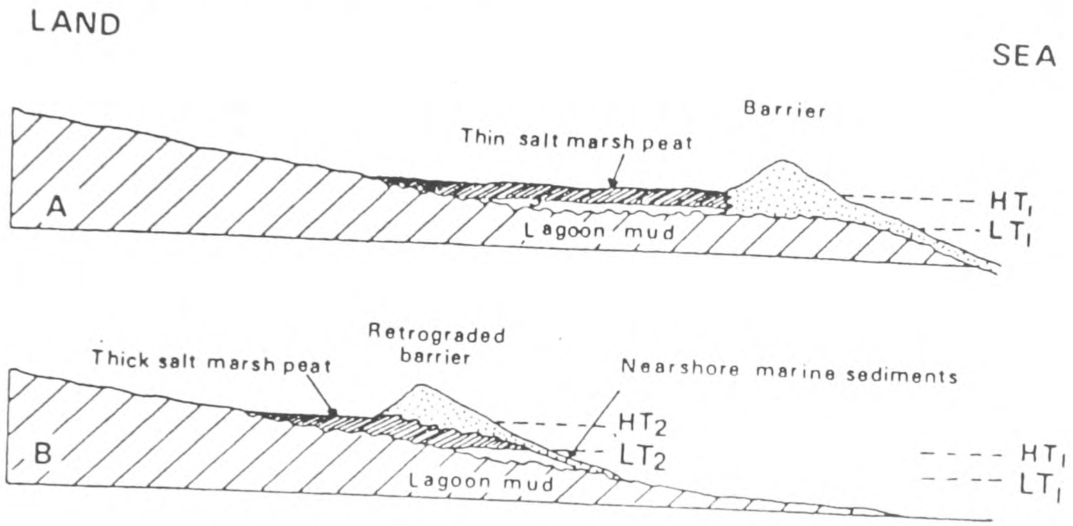
(4) When large waves reach the small wave-cut terrace some of the eroded material is carried out to sea and a proportion is thrown upward onto the terrace, forming a bar.

Gilbert (1885) investigated longshore drift as the barrier island forming process, suggesting that sand movement in the littoral or longshore system formed a spit which was later breached by tidal inlets. Fisher (1968) proposed this mechanism for northern U.S.A. barriers.

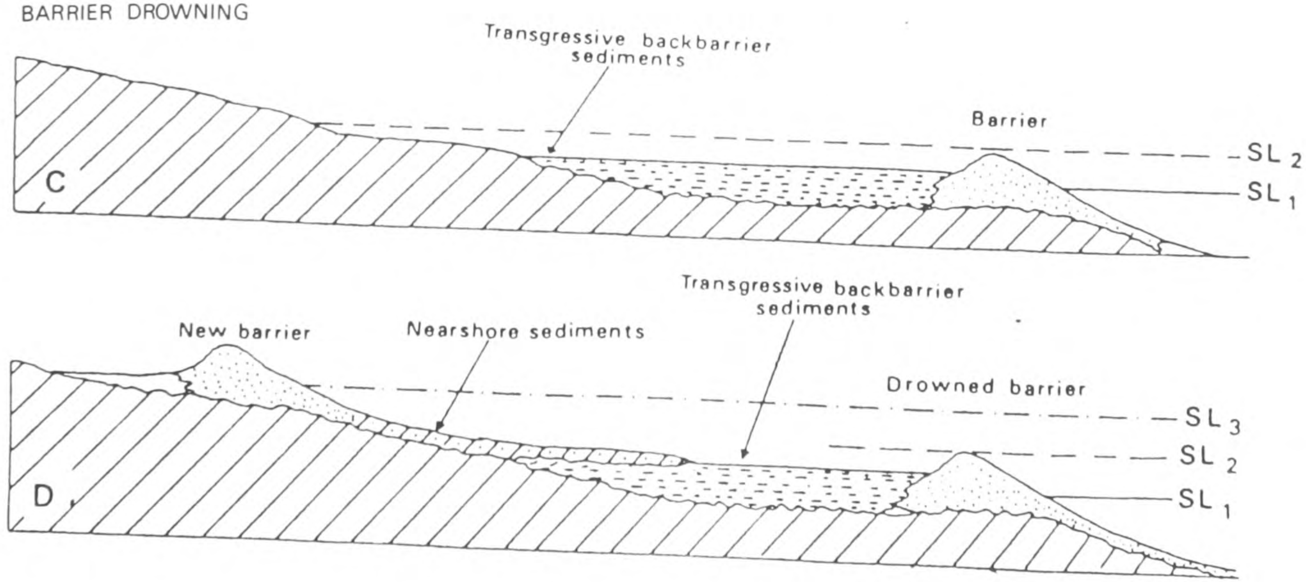
Submergence of coastal ridges by a rising sea level, leading to barrier formation was proposed by Mogel (1890) and favoured by Hoyt (1967) and substantiated by field evidence (Pierce and Colquhoun, 1970; Schwartz, 1975), indicating that present day barriers could have been formed by each of the above mechanisms in isolation or conjunction. A major problem of barrier origin is the linking of the migration of a barrier coast with continuous submergence and modification of the coast by wave activity and longshore drift (Swift, 1975; Sanders and Kumar, 1975). Theories proposed for the response of barrier islands to a marine transgression include continuous migration and in-situ drowning. The former postulates as sea level rises, the barriers migrate continuously landward, by the effects of shoreface erosion and washover on the landward side of the barriers (Fig.2.3). During migration, submergence leads to complete, or almost complete, destruction of the back barriers sediments, by wave re-working on the shore-face.

In-situ drowning implies that as sea level rises, the barriers may remain in place while the landward lagoon deepens and widens (Fig. 2.4). The breaker zone then reaches the top of the barrier and "skips" landward to form a new barrier shoreline along the landward edge of the former lagoon (Sanders & Kumar, 1975). The surf zone does not pass continuously across the back barrier area, resulting in only partial re-working of sediments by current on the self leaving a large part of the transgressive sequence on the self. Comments have been made (Leatherman, 1983) implying that the Vibracore evidence is unconvincing. Sanders (1963) proposed a super-construction theory, the superposition of recent sediments over the top of a Pleistocene core to form a new barrier, principally by inlet dynamics and overwash. In the process of shoreface retreat, the barrier would encounter the Pleistocene shoreline and become welded against the older ridge, so fixing the new shoreline until sufficient sea level rise took place to overtop the barrier, or continuous shoreface retreat caused the shoreline to

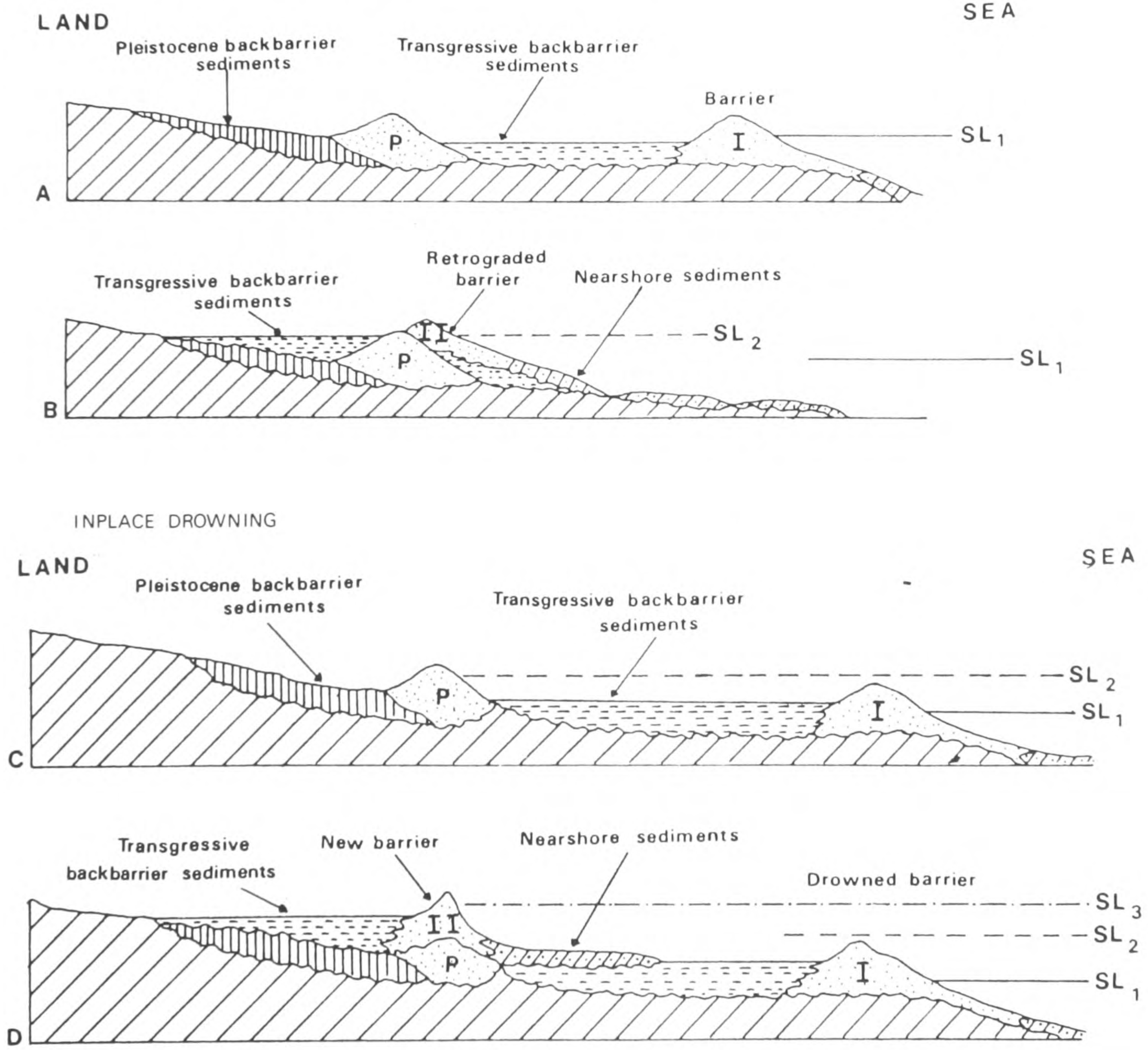
2.3. BÅRRIER RETREAT DURING SEA LEVEL RISE



2.4. BARRIER DROWNING



2.5. CONTINUOUS SHOREFACE RETREAT MODEL



migrate past the old barrier ridge (Fig. 2.5).

Rampino (1979) studied the south shore barriers of Fire Island and supported both main theories of landward migration, believing that a flow rate of sea level rise and adequate sediment supply produced shoreface retreat, while in-situ drowning resulted from rapid sea level rise and inadequate sand supply.

Controversy exists whether the coastline has actually migrated during the last ten thousand years. Sanders and Kumar (1975) have outlined a migrational history of Fire Island for the last 9,000 years, infering from seismic records that when sea level was 24 metres below present near sea level, a chain of barrier islands, similar in size and height to the modern shoreline, formed. As sea level rose, the barriers remained in situ, building upwards until sea level rose 16 metres (circa 7500B.P.). When the sea reached the top of the 24 metre barrier, the surf zone jumped 5km landward to form a new shoreline. The south shore barriers are also known to be migrating westward as sediment is eroded from the flacial bluffs and shoals at Montauk Point and carried by longshore drift, in a net westward direction.

An important consideration in S.E.M. analysis is sediment source. Are features seen, derived from an earlier sediment cycle or imposed during barrier formation processes? For Long Island, two sediment provenances have been suggested, one of which, offshore glacial lobes, is highly controversial (Williams, 1976). Net longshore drift for the south shore of Long Island accounts for approximately 300,000 - 600,000 cubic yards per year (Panzio, 1968) (Fig.2.6). The sand fraction of the moranial cliff material eroded at Montauk Point is thought to be the major source of littoral material for the Long Island transport system (Taney, 1961). However the present littoral rate of drift, 600,000 cubic yards/year exceeds the 100,000 cubic yards annually calculated for the eastern headlands section (Taney, 1961). This sediment budget discrepancy has been cited as an indication of an offshore glacial source. Wolff (1975) has further argued that the coastline shape and orientation suggest the presence of glacial outwash lobes.

The continental shelf off the south shore of Long Island (Fig. 2.7) is a shallow sloping seaward plain approximately 80 miles

FIG 2.6 Estimates of littoral drift at inlets $yrd^3/year$

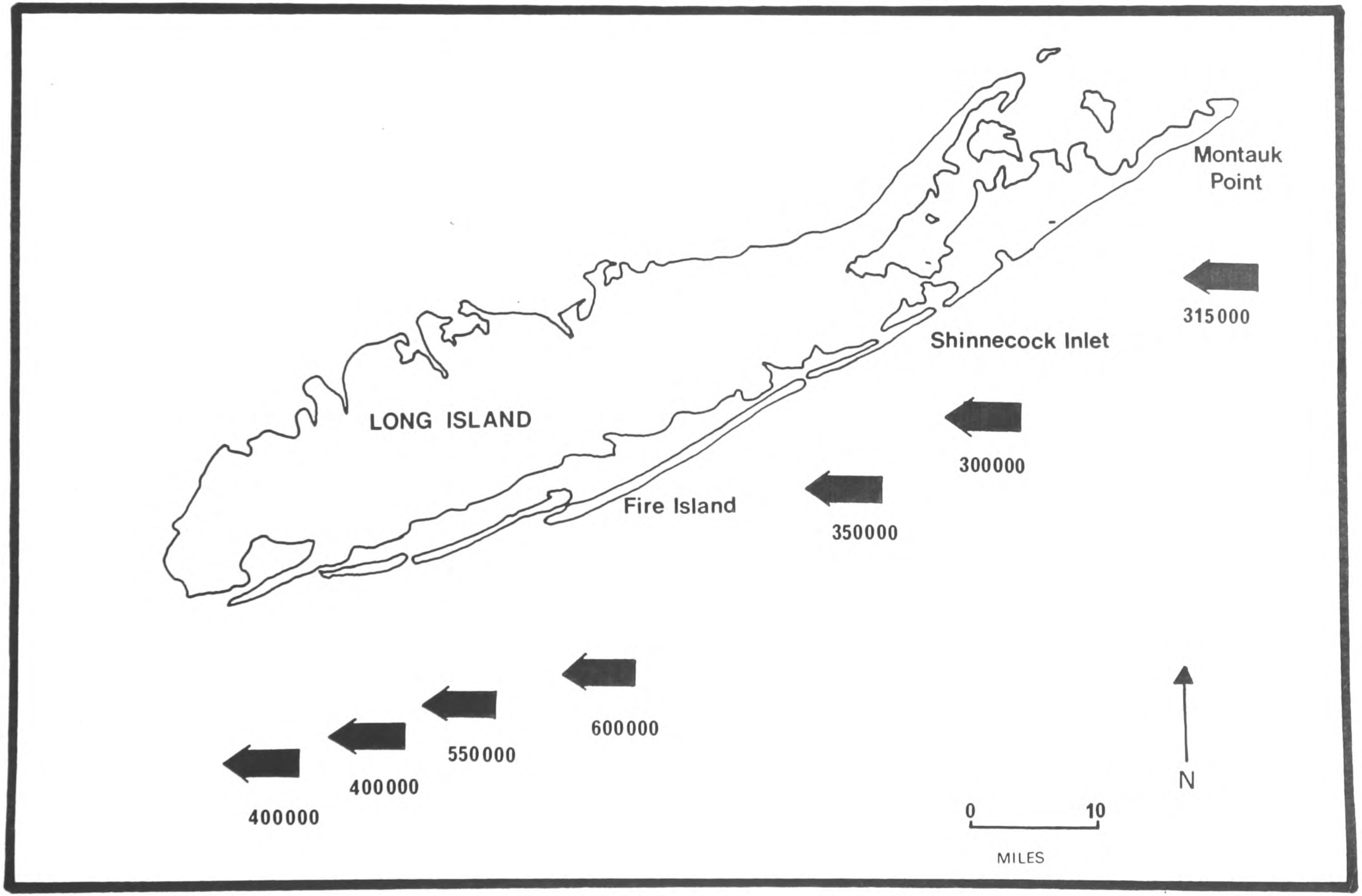
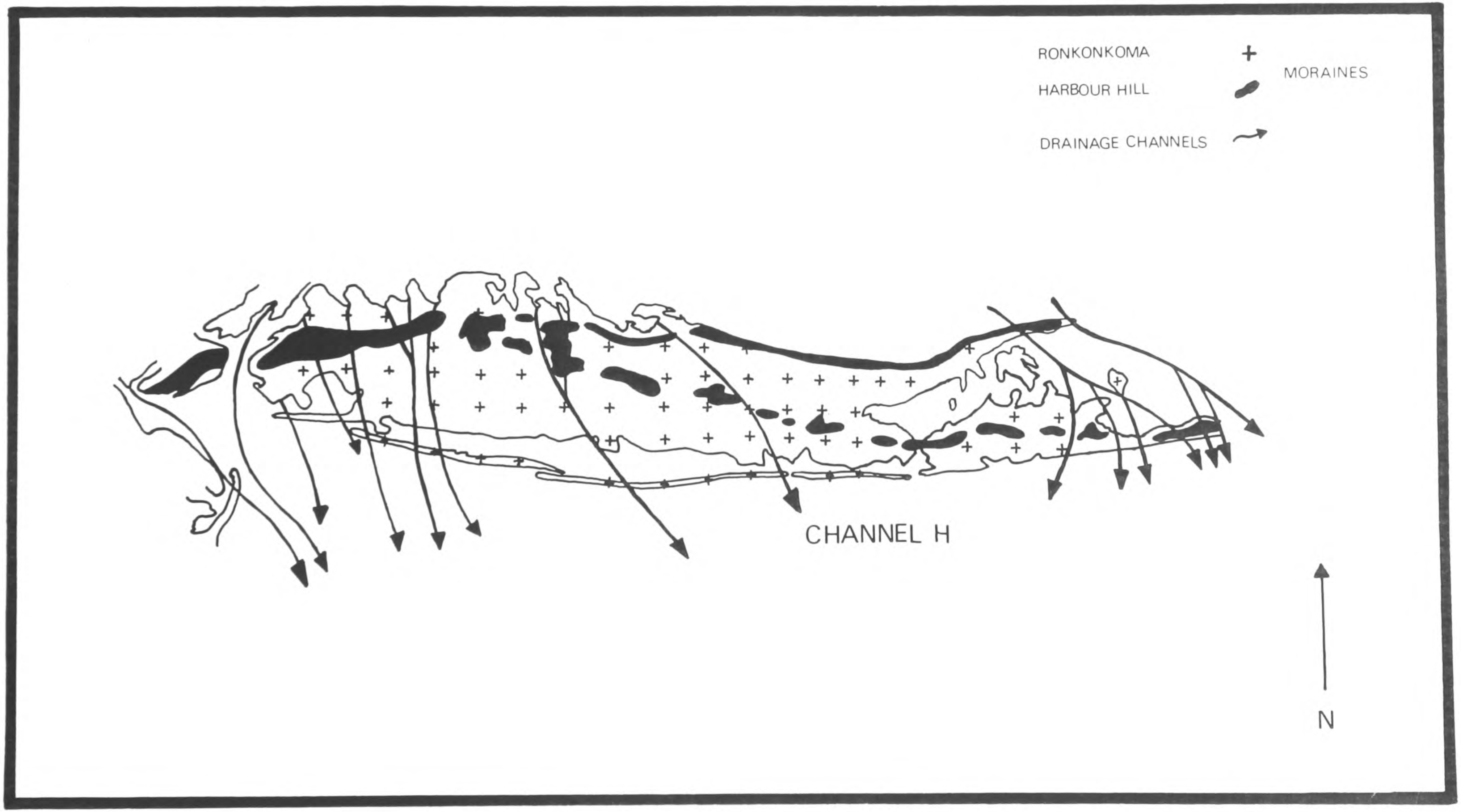


FIG. 2.7 CONTINENTAL SHELF OF LONG ISLAND



wide from the coast to the shelf edge. The shelf is flanked on the west by the Incised Hudson Channel, on the east by the broader Block Channel. The 60-90-12 foot contours widen to the south east and show a prounced ridge and swale morphologic fabric, with a N.W. - S.E. crestal orientation. The glacial depositional landmass consisting of the Harbour Hill and Konkonkoma moraines coalesces to the south and extends onto the shelf. The sediments are primarily stratified blanket like deposits of quartzose sand and gravel, discontinuous in aeriel extent (Williams, 1976). Fifteen major buried drainage channels are incorporated, ranging in depth from 100ft - 700ft, hundreds of feet to several miles wide. Overdeepening is evident due to the lobes selectivly following pre-existing stream channels, infilling with associated sediments that influence much of the present Long Island Topography (Williams, 1976).

Once offshore sediment reaches the beach shoreface it serves as a major source for nearshore processes including overwash and flood tidal delta formation. Between 13% and 22% of material eroded from an active beach profile is added to the backshore (Schwartz, 1975). Residence time and geologic features of material moved to each nearshore 'sink' vary greatly.

2 (iv) MAIN GEOMORPHIC PROCESSES

2 (iv) (a) Introduction

The Barrier Chain enclosed numerous smaller estuarine sounds, bays and lagoons and a strong interdependence exists from one barrier to the next. As such the system interacts throughout its entire length and is both a product of and response to similar energy regimes and resulting processes. This culminates in a complex interacting coastal network. Although each geomorphic environment is considered independently this is obviously not a true reflection of the system. The underlying premise of distinctive suites of surface features produced by uniquely associated energy conditions demands an understanding of process and form. To consider each process seperatly denies this dictum. Sand grains themselves reveal textural superimposition which directly reflects the inter-relationships between processes. Whether those processes combine in a similar way in all the sediments is a fundamental question to be answered. Do the processes exert similar or disproportionate control upon sediment despostion and is this reflected in the sediment history?

The three most important processes in barrier dynamics are (a) overwash, (b) inlet, and (c) flood tidal delta formation. Aeolian and beach processes play a reduced part in sediment deposition. The distinction between overwash and inlet formation is gradational since the processes are genetically related. Barrier topography, width, lagoonal size and depth and type of coastal storms are among the factors that determine washover fan or tidal inlet formation. The relationship of washover to storm induced beach erosion involves a redistribution of eroded beach mass.

During a storm most beach material eroded and removed from the zone of normal wave influence is deposited into alongshore or offshore sinks. A certain percentage is transported landward by washover or flow through inlets. Whether the beach component can be defined in the overwash and tidal delta samples using the S.E.M. is open to question. Further complexities arise as associated aeolian storms transfer some beach material onshore or offshore, the fluvial sediments may then contain aeolian textures.

2 (iv) (b) OVERWASH

Overwash may be defined "as the continuation of the wave uprush over the crest of the most landward (storm) berm" (Shepard, 1963, P. 26). Leatherman (1979, P.20) redefined overwash as 'any swash surge that passes over the 'crown' of the barrier beach; the 'crown' being the line that connects the highest points along a barrier, generally equated to the frontal dune line (Fig.2.8). When barrier dunes are absent the most landward storm berm would be the threshold overwash.

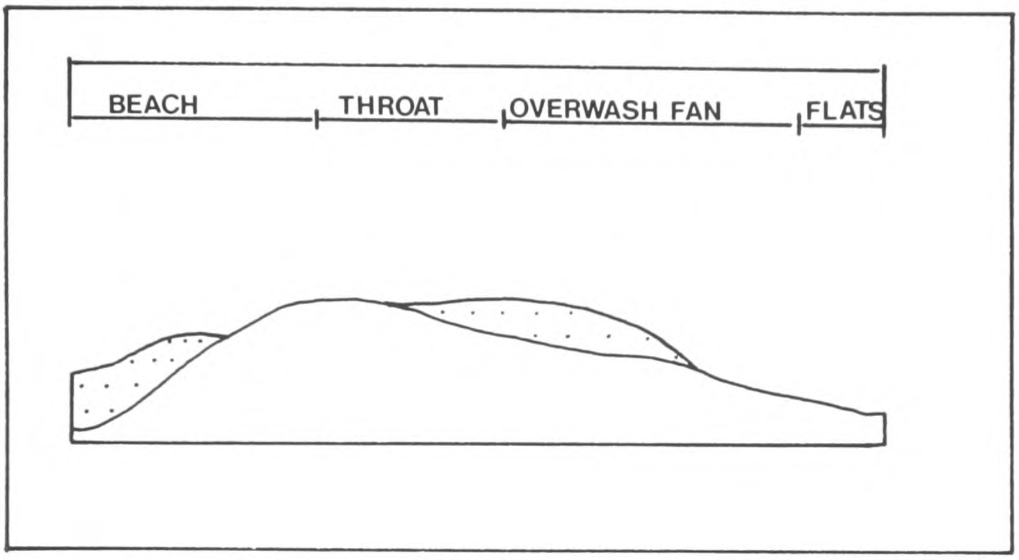
The beach zone is totally flexible and moulds itself to the energy regime of the ocean and responds to any energy change, by producing a three-dimensional profile that is in equilibrium with the specific energy regime (Riggs, 1976). Berm building is one such short term response, with changes in height and dimensions controlled by seasonal wave patterns and storm induced events. During periods of high energy levels, dunes become the storm berm and overwash becomes the active process. Leatherman (1981) refers to overwash as a process creating washover (the morphological feature formed) while Riggs (1976) refers to washover as the process thus highlighting confusion in the terminology.

Water breaking over the top of a storm berm carries a significant amount of sediment over the backside producing a broad structural washover fan. Only when a storm berm is flattened by destructive waves, superimposed upon a storm surge which breaches a dune, is a washover fan exposed to hydraulic action and sediment transported through the dune. This process moves an island landward and upward in space and time and on many beaches, is an important structural part of the storm beach, the basic mechanism for the construction, maintenance and migration of the back dune region of the barrier. Wherever there are low barrier shorelines, overwash activity can be expected with the present eustatic rise in sea level, but the extent of overwash activity varies regionally due to differences in tidal range, wave, climate, sand supply and texture.

The overwash process has certain characteristic physiographic features (Fig. 2.9). The narrow breach or channel through a dune field is the throat. As overwash surges across the dune line, additional sediment

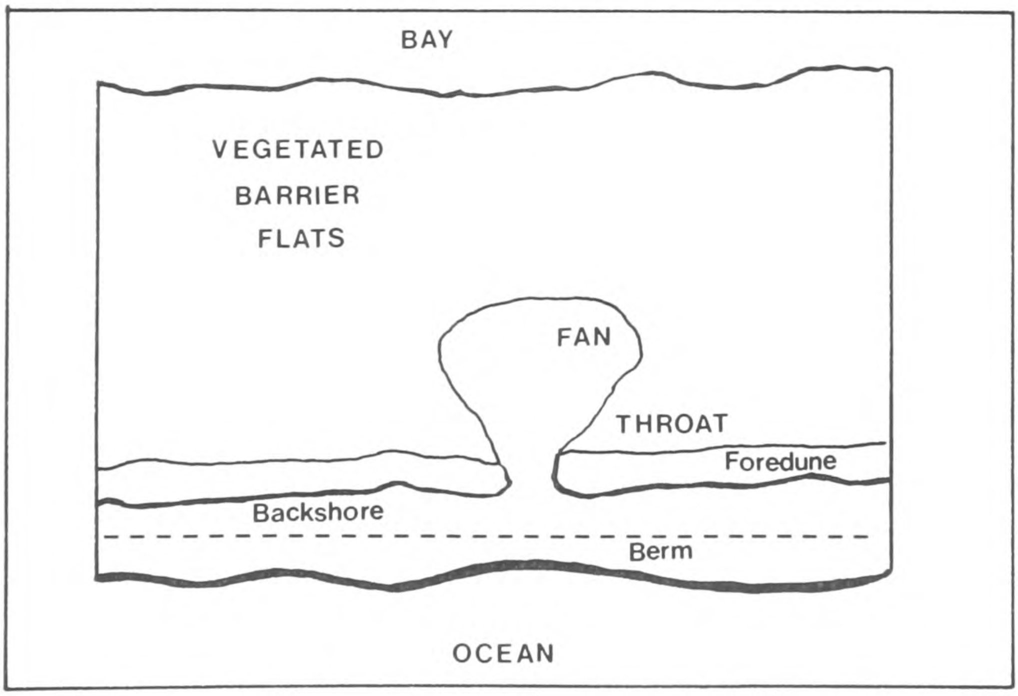
FIG 2.8

Physiographic features of overwash processes



BARRIER CROSS SECTION

2.9



is eroded from the throat, transported landward and deposited in a fan to the dune leeside. During a very severe storm, large sections of barrier dunes may be overtopped and flattened forming extensive washover flats. The fan is the washover portion on an island interior where the deposit is allowed to flare, due to lack of horizontal constraints. Sluiceways, acting as channels for waterflow from the washover fan to the bay, often lie at the water table and contain dense vegetation. If overwash penetrates across the island to the bay, sediment will be deposited as a subaqueous washover delta. The flood storm surge is believed to be essentially depositional except in the throat. Surge velocities are reduced due to flow divergence, friction and precolation losses (Leatherman and Williams, 1982) and deposition occurs on the salt marsh.

Over the short term overwash may appear catastrophic, placing severe stress on the barrier environment. Viewed over the long term, (hundreds of years), overwash is a nearly continuous process, shaping and reshaping the barrier, Where sand supply is reduced, the barrier remains small and is easily rolled over into the adjacent lagoon by overwash. Sand starved barriers become lower and narrower thus increasing the rate of washover and throughflow by inlet dynamics, accelerating the retreat process (Leatherman, 1979). Vertical accumulation of sediments is therefore a function of the interaction between overwash and aeolian processes and plant communities. Where dune establishment is prevented, the barrier remains low and is easily moved landward by overwash.

Frequency of overwash depends on storm occurrence, tidal range and dune dimensions with the amount of overwash at any locality, a function of surge level and back barrier topography. Where tide ranges are low and storm frequency high, overwash is a frequent event, but where tide ranges are large, chance that a storm will arrive at the highest tide levels and overtop the barrier is considerably less and overwash becomes an infrequent event. Where there is a balance between overwash and aeolian processes the result is sediment homogenization from different depositional environments. The washover fan then serves as a temporary reservoir before redistribution of the sand. A comparison of historical aerial photographs (Leatherman, 1979) showed that the greatest island width and highest rates of landward migration, are associated with inlet dynamics, and overwash only becomes an effective transport mechanism for island migration, where the barrier width is less than a critical value, e.g. 400' - 700', at Assateague Island, Md., U.S.A.

2 (iv) (c) INLETS

"Inlets are temporary waterways, through a coastal obstruction such as a reef or barrier island, which connects the open sea or lake waters to a bay or lagoon" (Gary, et al 1977 - P.178). In contrast overwash occurs as a result of ocean or bay storm surges and does not generally occur under the influence of astonomical tides along. Inlet formation is generally caused by bay storm flood waters overtopping low portions of the barrier, creating linear channel forms, as compared to the more sheetlike overwash forms.

When barriers migrate continuously landward the zone of shallow water waves transgresses the shelf and the rising sea reworks all the intervening sediments on the shelf. In the event that the barriers move discontinuously by 'drowning' during a rapid rise in sea level, the zone of the shallow water waves jumps landward and 'skips', re-working the lagoon sediments (Swift, 1968). Sediments deposited in barrier environments lying below sea level which cannot be eroded by waves stand the best chance of being preserved in the shelf sediment record. Thus, sediments deposited in either (a) laterally migrating tidal inlets, or (b) sediments on the toe of the barrier, stand maximum chances of preservation after a transgression (Kumar, 1973).

Tidal inlets are breaks in otherwise continuous chains of barrier islands which allow tides to flow in and out of the lagoon. Inlets migrate laterally by considerable distances within very short periods (hundreds of years), depositing thick channel deposits. The hydraulic conditions in a tidal inlet differ according to depth in the channel during lateral migration.

Inlets are characterised by mixed sediments with components from beach, nearshore and lagoon environments. Sediment characteristics differ in inlets which have been closed siddenly at the mouth, or are migrating parallel to the shore, by depositing a different percentage of sand and clay.

In considering the stratigraphic relationships of these sediments, Hoyt and Henry (1967) and Swift (1968) found that a tidal channel forms the deepest area in barrier island chains. Under suitable conditions the inlet migrates paralled to the shore, with the flood part of the tidal cycle carrying sediment into the lagoon, depositing it at the mouth of the channel as a flood tidal delta. Though the bottom shoals on the seaward side of the channel, no delta builds, as longshore currents/waves virtually always wash off all the material. Profiles along the length of a channel is of a broad V, with the deepest section in the channel middle, just adjacent to the barrier island, with a tidal delta on the lagoon side and shoaling of the seaward side channel. As an inlet migrates the V-shaped profile is carried perpendicular to the shore, depositing a prism of sandy material, whose formation is preserved, as the depth is greater than the depth to which wave attack is capable of scouring.

Five major inlet facies units have been tentativly recognised (Kumar, 1973):

(a) Channel floor - Characterised by a lag gravel composed of large shells, pebbles, etc.

(b) Deep channel - Comprising lenticular sets of ebb-orientated, cross laminae bounded by flood orientated reactivation surfaces.

(c) Shallow Channel - With plain parallel laminae.

(d) Spit Platform - Steeply dipping plane cross laminae.

(e) Spit - With steep and gentle seaward dipping laminae.

Fig. 2.2 has shown the major inlets to be found along Fire Island. Historical records dating back to the early C17 document the formation and closure of many inlets through the spit/barrier island system. After storms in 1690, Fire Island inlet was 9 miles wide. The two present day inlets, Moriches and Shinnecock, are both known to have been opened by storms in March 1931, closed in 1951 and reopened by dredging in 1953 (Jonecki, 1969). Four former inlet sites are suspected.

The inlets demonstrate a natural orientation approaching North - Northeast by South - Southwest and in most cases this orientation is not produced when the inlet is initially opened but developes in response to storm winds blowing across the bays from a North - easterly direction. Hurricane paths determine the wind patterns in specific areas and therefore the effectiveness in orientating the inlets, the crucial factor being the passage of the eye of the storm over Long Island.

FIG. 2.10

CHANGES IN FIRE ISLAND INLET BETWEEN 1834 AND 1955

(KUMAR 1973)

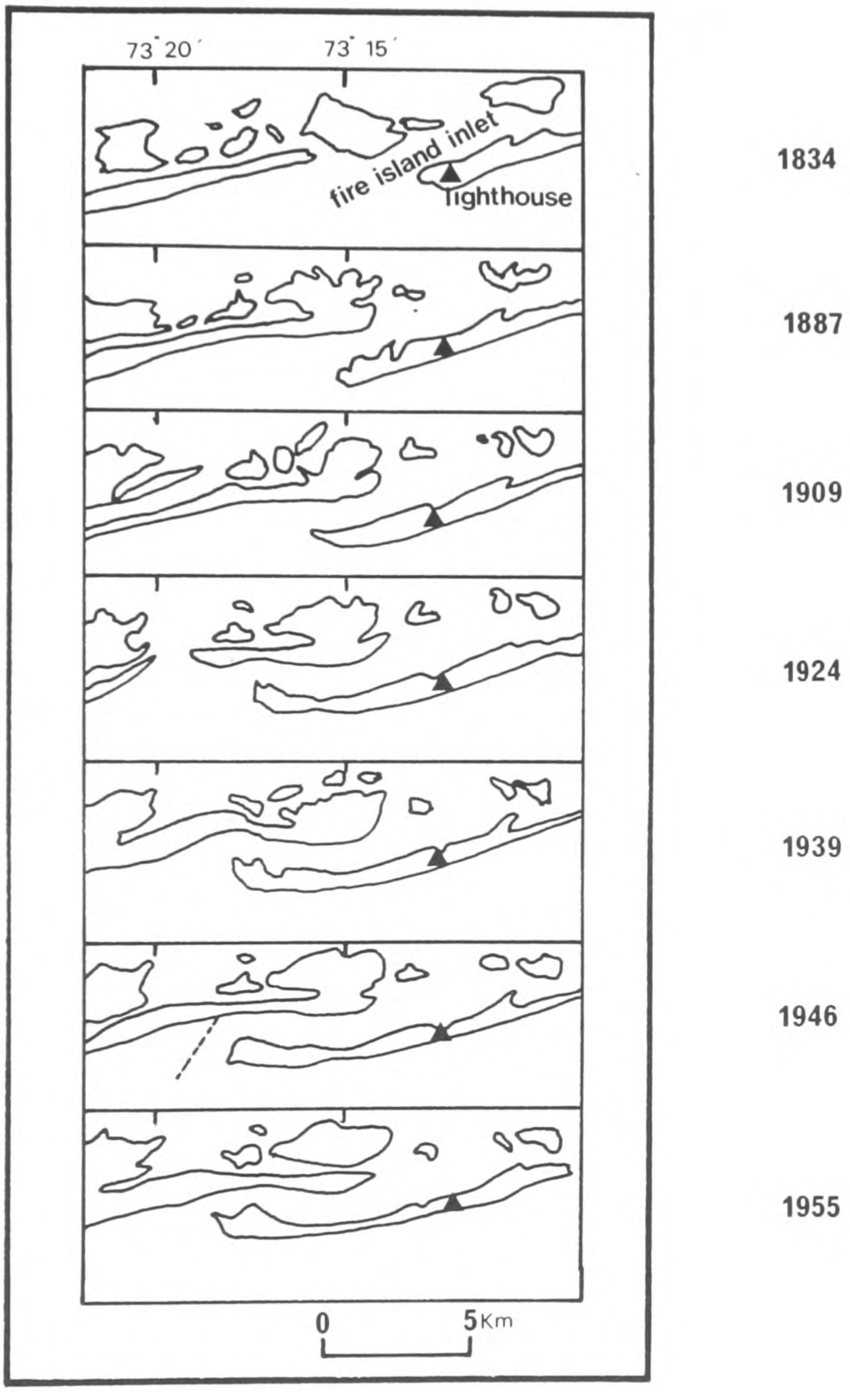


Fig. 2.10 shows shoreline changes in Fire Island inlet between 1834 and 1955. In 1834 the inlet appeared to be a simple undrift offset type but in 1909, the updrift side had extended over 10,000 ft to the west and overlapped the downdrift side, leaving the inlet channel as a deep gorge, that was eroded at 40'/year.

Although overwash is an important process along retreating coastlines, the contribution by inlets to barrier island migration has not been clearly assessed (Leatherman, 1979) due to the infrequent nature of inlet activity. The widening of barrier islands at inlet sites is a result of a large increase of sediment applied to the back barrier, culminating in development of flood tidal deltas. Sand transported as littoral drift and shelf derived silts and clays in suspension are intercepted by the inlet tidal jet, to be carried through the inlet channel to the quieter lagoonal waters. Fig. 2.6 has shown estimates of amounts of littoral drift for each of the six inlets along the south shore of Long Island.

Approximately 33% of the 235km stretch of Fire Island can be associated with inlet activity. Inlet migration, as a bi-directional displacement over time, gives rise to complex sedimentary patterns.

2 (iv) (d) Flood Tidal Delta

When open, an inlet acts as a complex or partial barrier to longshore sand transport. Depending on equilibrium conditions an inlet may trap sand or naturally bypass a large portion of the littoral drift, and with rising tide, sand that has been moving as littoral drift is interupted by the tidal current. A portion of this material will be transported through the inlet for deposition in the bay. For this reason it is envisaged that these samples would reveal more complex textural assemblage on the grains, due to the increased environments through which sediment has passed.

The flood tidal delta exhibits a deltaic pattern when fully developed. With inlet closure or migration the delta becomes prime substrate for salt marsh development. Flood tidal deltas play a major role in building a structural base upon which a barrier island will migrate in response to rising sea level. The sand shoals, which build up to high tide level, become the substrate for aquatic vegetation.

Upon closure or migration, the vegetated shoals continue to trap fine sands and organic matter, evolving into an expanding intertidal salt marsh along the backside of the barrier island. Barrier island migration takes place with continued shoreline recession along the front side, while the flood tidal delta shoals and salt marshes supply a structural nucleus for the progressive island build up through storm washover and windblown sands.

Fig. 2.11 shows the process of inlet breaching, migration, closing and development of a large flood tidal delta in Long Island (Leatherman, 1976). Flow of super-elevated water in the bay, driven by strong northwest offshore winds results in the creation of an inlet. Normal tidal currents through the inlet throat, with change in tide, results in the creation and initial growth of a large flood tidal delta in the bay, which grown with sediment accumulation. Net longshore currents to the south, results in migration of the inlet southward producing an increased size and growth of a delta. Eventually the water path through the inlet throat area becomes so long and tortuous that inlet efficiency is greatly reduced. Flushing of sediment from the inlet throat by tidal currents is overpowered by deposition of sand in the throat caused by the longshore current, resulting in the inlet closure. Fig. 2.12 shows the typical morphology of a flood tidal delta (after Hayes, 1976). It should be noted that at, for example, St. Josephs Island, Texas, tidal delta development is not initiated until stable, narrow tidal inlets are formed (Andrews, 1970). Until this stage, the exchange of water between the Gulf and the bay occurs via many wide inlets. As the tidal range is so large water exchange is readily accomplished and tidal currents are too weak to move sediments. With restriction of the inlets in width and number significant tidal currents are generated and sediment is moved in and out of the bays through the inlets, forming flood tidal deltas.

2 (iv) (e) Aeolian Transport

The importance of aeolian deposition in coastal areas is demonstrated by the size and bulk of coastal sand dunes in many areas with smaller sand dune accumulations, an integral part of almost all depositional coasts.

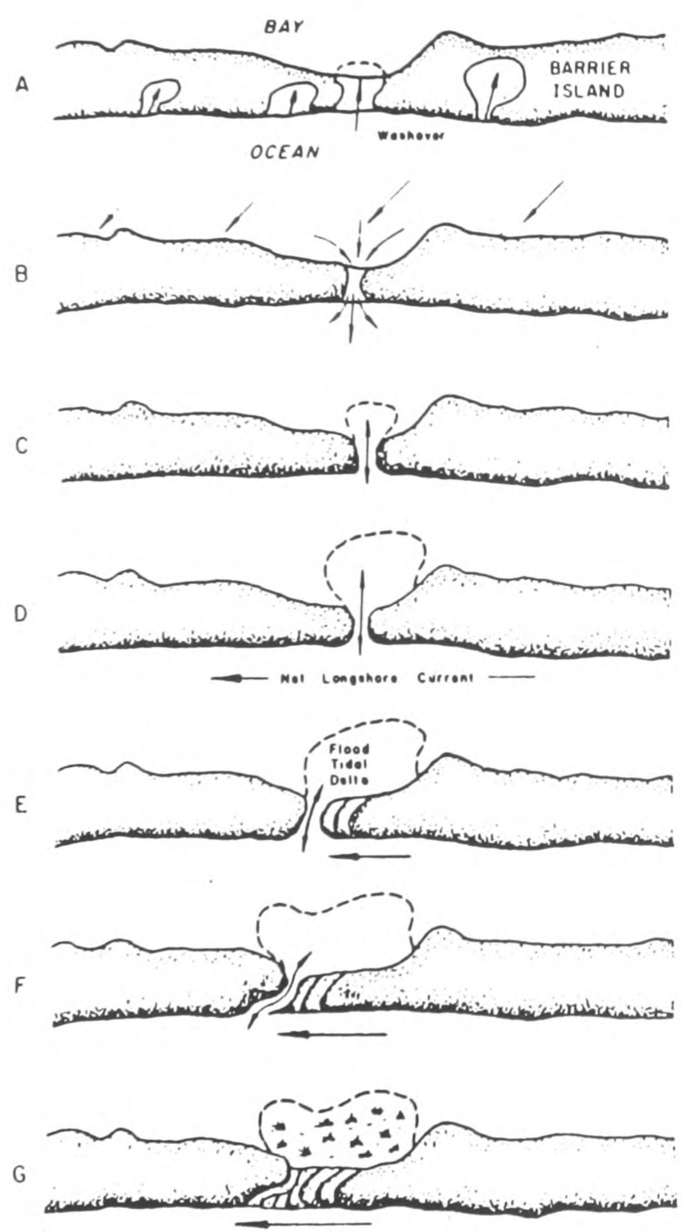


Fig 2.11 . Sequential diagrams showing the process of inlet breaching, migration, closing and development of large flood tidal delta.

(A) Initiation of storm causes wave overwashing of barrier island at low places in dune lines.

(B) Flow of superelevated water in the bay, driven by the strong (northwest) offshore winds near the end of the storm, results in the creation of an inlet at low, narrow points along the island.

(C) Normal tidal currents through the inlet throat, with change in tide, result in the creation and initial growth of large flood tidal delta in the bay.

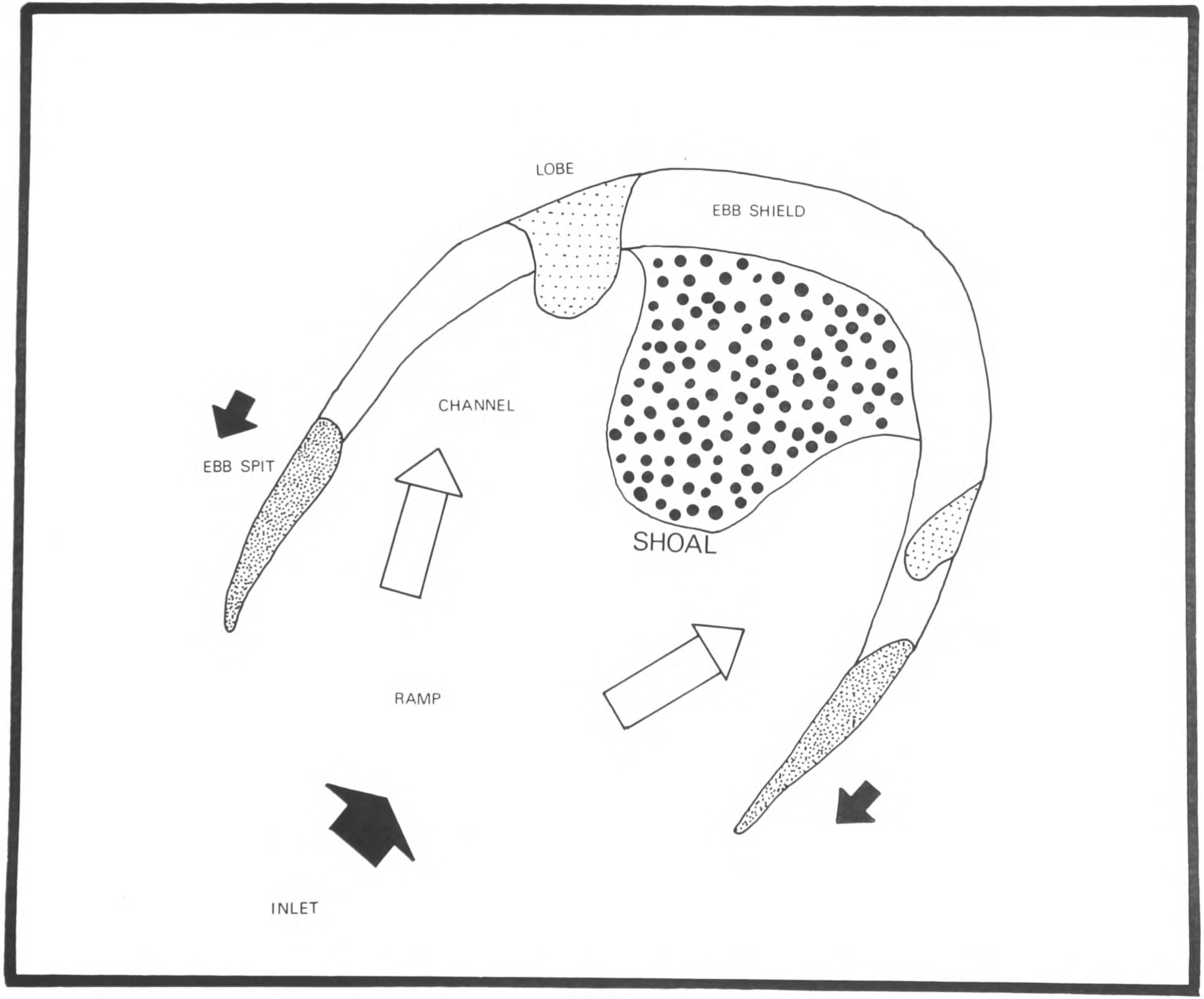
(D) The flood tidal delta continues to grow as sediment accumulates in the bay. The ebb tidal delta on the ocean side is also present, but not prominent, due to disturbance by ocean waves.

(E) Net longshore currents to the south result in migration of the inlet southward, resulting in the increased size and growth of the flood tidal delta.

(F) Eventually the water path through the inlet throat area becomes so long and tortuous that the inlet's efficiency is greatly reduced.

(G) The flushing of sediment from the inlet throat by tidal currents is overpowered by the deposition of sand in the throat caused by the longshore current, and the inlet closes. The new sediment on the bayside (flood tidal delta) provides an ideal substrate for marsh growth and the island has been effectively widened at this point by the process of inlet dynamics.

FIG 2.12 MORPHOLOGY OF A FLOOD TIDAL DELTA



Sand dunes may occur where there is a large supply of sand, a wind to move it and a place in which it will accumulate. Coastal sand dunes may be described and classified on the basis of either (a) description, (b) genesis (Goldsmith, 1971). The two main types of coastal sand dunes are (a) vegetated dunes, (b) transverse dune ridges. Coastal dune occurrence appears to be unrelated to present climate but directly related to sand supply and favourable wind regime. The sediments are moved to the shoreline and deposited on the beach by longshore currents and waves. The sediments are then picked up and transported by wind at low tide. A coast with a large tidal range promotes sand dune development because sand deposition is spread over a much larger intertidal area. It is suggested that an additional source of dune sand is storm overwash deposition.

In wind velocity terms there is a simple relationship between the directional distribution of wind velocity and sand dune development. The dominant or highest velocity, less frequent winds, may move more sand per unit time than the lower velocity more frequent prevailing winds but due to a much lower frequency, the dominant winds may not be as important in dune development as the prevailing winds. The shoreline orientation with respect to both dominant and prevailing winds is also critical.

The most common type of coastal dunes are vegetated dunes generally in the form of ridges with flat to undulating upper surfaces, and continuous but irregular crests often punctuated by blowouts and washover sluice channels. Transverse dune ridges, or migrating dunes are characterised by a lack of anchoring vegetation and move generally landward, in response to prevailing winds.

Wind driven dunes may be an important factor in the landward retreat of some barriers but although dune forms, representing thousands of acres of open blowing sands are presently moving inland at rates of approximately 20ft/year (e.g. Nauset Spit, Cape Cod) dune migration is not equated with barrier migration, and therefore landward migration by aeolian processes is rather limited in most situations, depending upon barrier orientation in relation to prevailing wind directions.

Most north - south aligned barriers, e.g. Nauset Spit, experience net seaward aeolian transport due to prevailing north - west winds, (Leatherman, 1979). These offshore winds rework the washover deposit, blowing much of the sediment off the fan back towards the beach, into newly developed drift line initiated dunes. In the case of small washover fans over half the aeolian transported sediment is deposited on adjacent dunes (Zaremba, 1982). Where drift line plants have not been successfully established, large barrier washover flats are continually affected by wind with most of the sand returned to the beach and swash zone by offshore winds.

Dune formation models for the New Jersey coastline have been developed by Gares et al (1979). Storm conditions produce onshore winds (North-easterlies and easterlies) and associated high waves and storm surge. The onshore response is shown in Fig. 2.13. Depending on conditions, water may;

(1) flow up the dune scarp eroding material from the beach and dune, carrying it to the nearshore,
(2) flow up to and over the dune scarp, eroding material from the beach and dune, depositing it over the dune crest,
(3) flow through low points in the dune, eroding material from the beach and the throat, and depositing it in an overwash fan.

In the post-storm/offshore wind model (Fig. 2.14) wind is the dominant process and the role of water is negligible. The dominant winds (north-westerlies and westerlies) move sand from the washover fans to the areas to the back of the dune crest, accumulating where vegetation causes a decrease of wind velocity. Some of the washover sediment may be carried back through the throat and deposited on the beach or in the nearshore area. Wind also removes sediment from the beach face and carries it to the nearshore.

While aeolian processes are limited in their potential for landward sediment transport and barrier migration they play a significant role in vertical sediment accretion (Leatherman, 1981).

2 (iv) (f) Beach

Along coasts where sediment is abundant, there is normally a beach between the nearshore zone and land. A beach may be defined as a

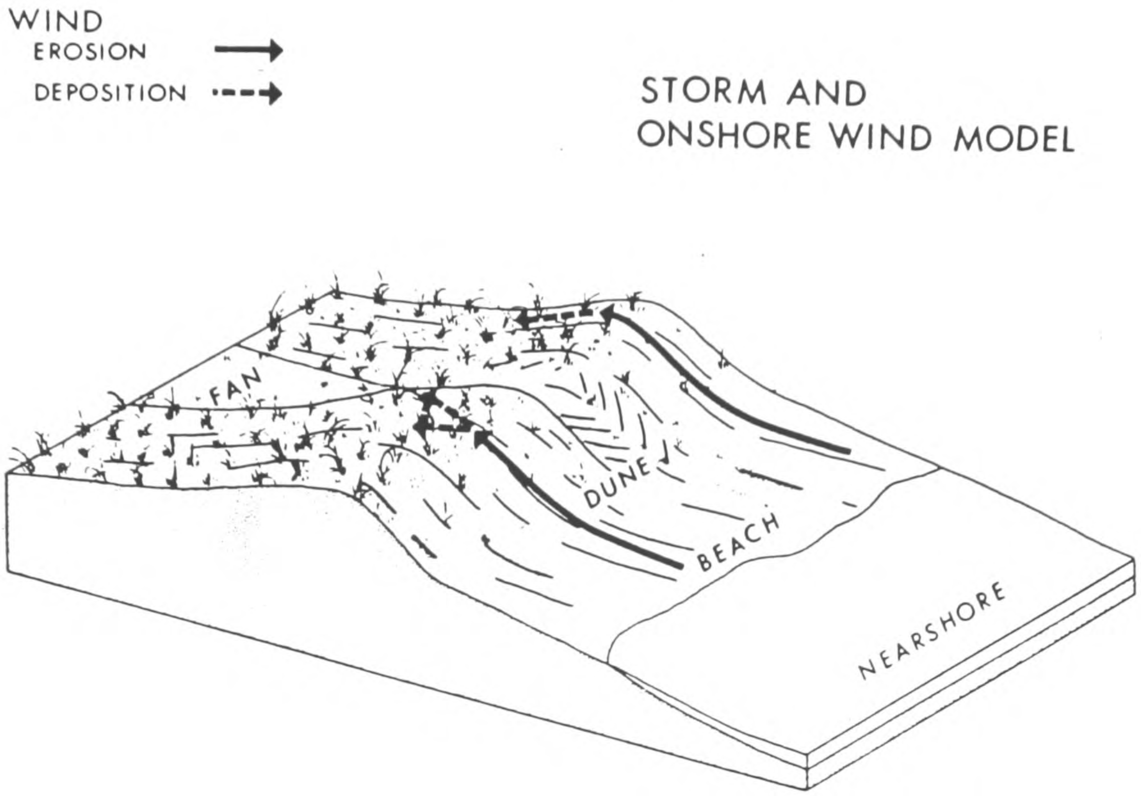


Figure 2.13 Dune formation processes during an onshore wind period.

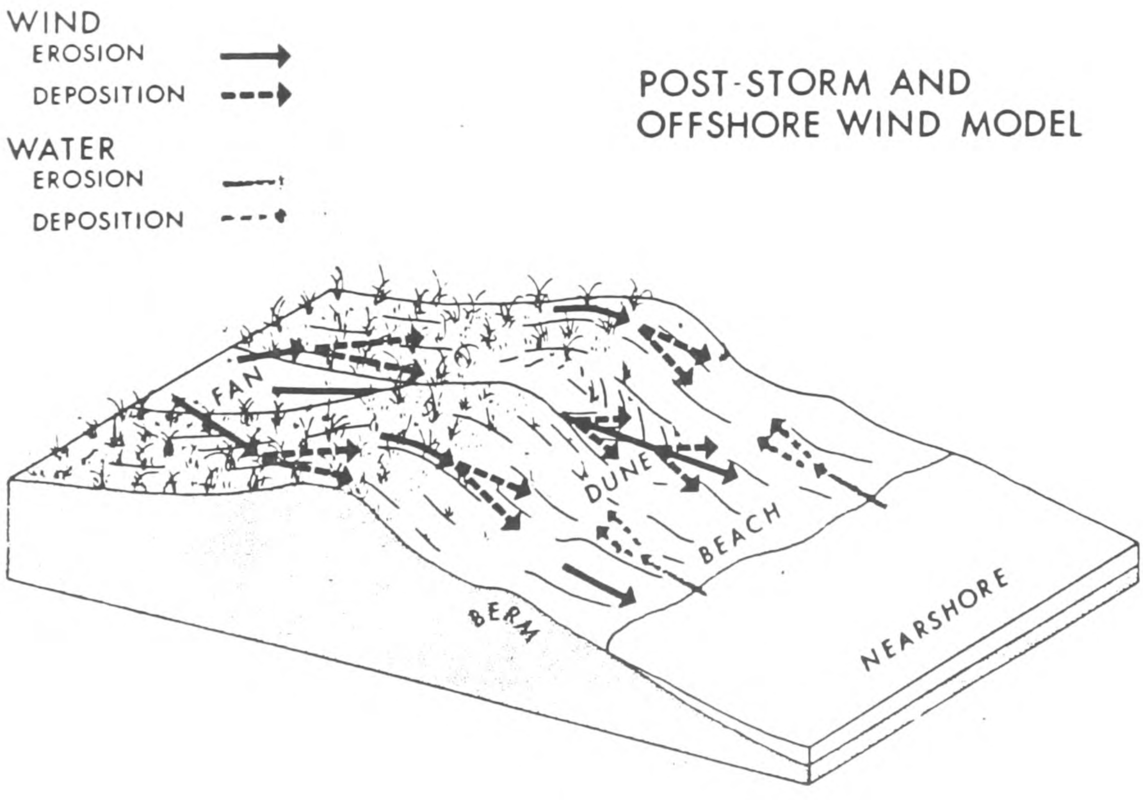
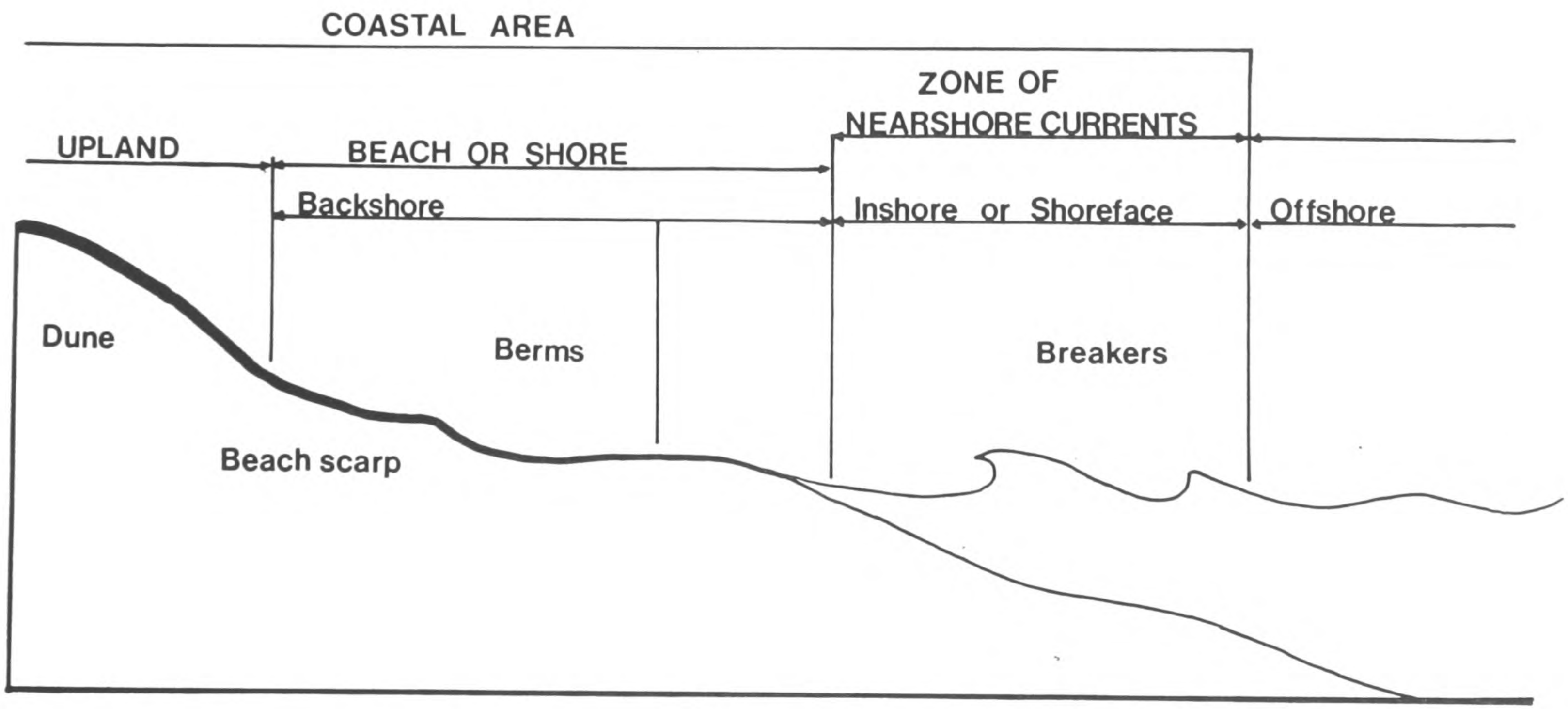


Figure 2.14 Dune formation processes during an offshore wind period.

FIG. 2.15 3-D. FEATURES OF BEACH AREA



body of wave-washed cohesionless sediment (sand size or coarser) which extends along a shore between the outermost breakers and the landward limits of the effects of water from breaking waves (King, 1951). This definition is based on the concept that the distinguishing features of a beach result from the effects of breaking waves and therefore a beach includes components that are underwater or subaerially exposed.

A beach builds a widespread lithologic unit by lateral accretion with beach faces built outward by addition of new sediments, and deposited in zones that reflect the processes of deposition. Although the zones are arranged in the same fixed order, they are foremost dynamic in nature. Morphological subdivisions of beaches include various three-dimensional features (Fig. 2.15), including the backshore, foreshore, shoreface and sand dunes, with the boundary between backshore and sand dunes located near the lower limit of the dunes, with the backshore extending up to the mean high water line.

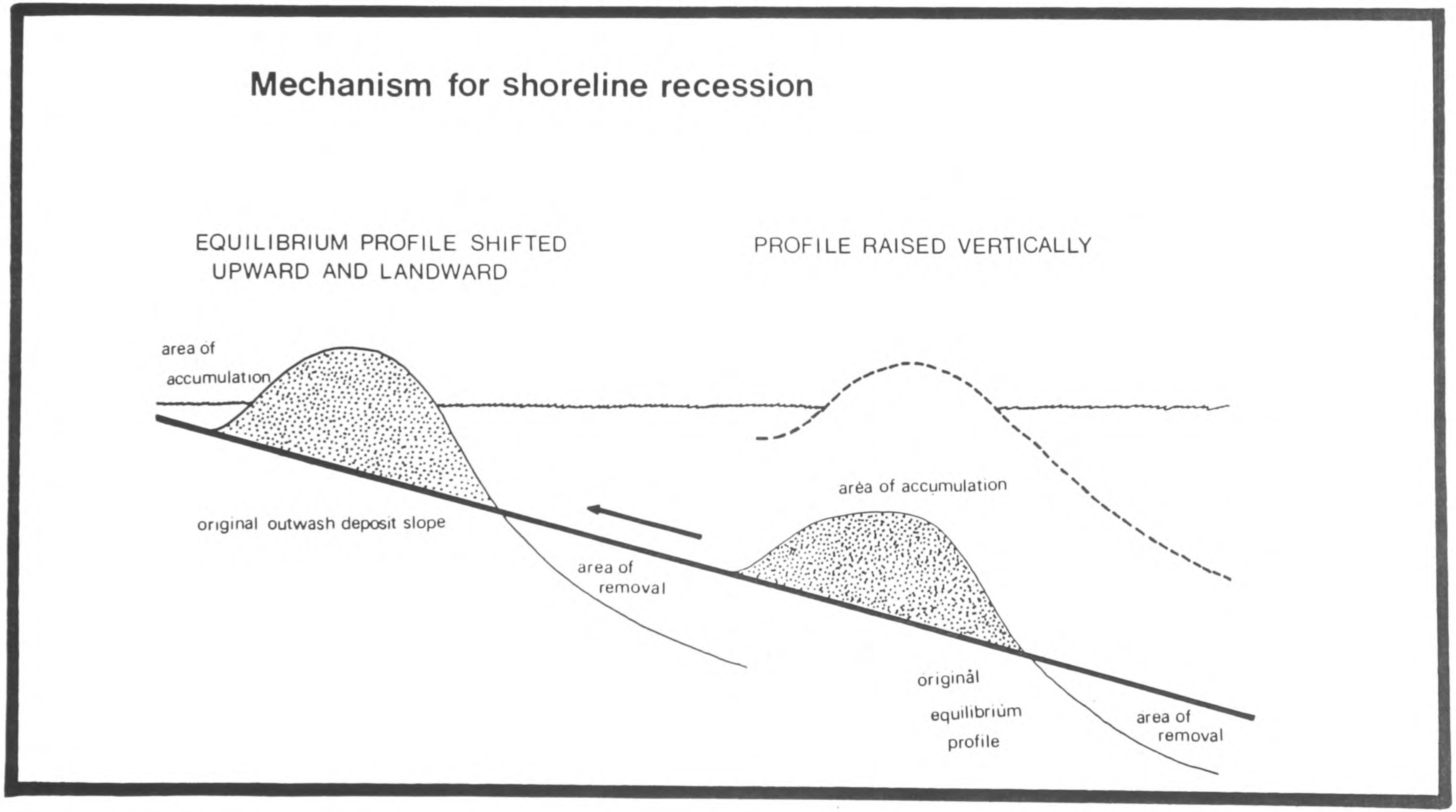
Wave energy is the major factor controlling beach development. Some degree of tidal influence is ubiquituous. On most coastlines the tidal range is between 2 and 4m (mesotidal) but a limited number have ranges less than 2m (microtidal). The beach is totally flexible and moulds itself to the energy regime creating a three-dimensional equilibrium profile. The backshore is the zone above high-tide mark and is only inundated during storms. The foreshore is the intertidal zone which is dominated by swash zone processes. A high rate of water flow generates current - irreated plane beds while a low rate favours the formation of ripples. Occasional layers of heavy minerals are attributed to grain segregation in the repeated swash and backwash flow. The shoreface is the subtidal part of the beach face.

The natural conditions for beaches and barrier islands contain a wide range of responses to various wave conditions adjusting the profile accordingly. Incoming waves at a shoreface begin to steepen after 'bottoming', prior to oversteepening and break up in the breaker zone. During storms and longer length waves effective wave bases reach deeper parts of the shoreface profile. Surf zone presence and width is controlled mainly by beach angle slope and tidal phase. In this zone rip currents transport coarser sediment towards the breaker zone, coincident with sediments brought into the breaker zone.

If waves reach the beach at low angles, stronger longshore currents are produced resulting in active sediment transport parallel to the coast. Any grains which are inequilibrium in the surf zone and with longshore current are transported along the coast, the so-called Null Point hypothesis. The concept of the marine profile of equilibrium considers a balanced sediment supply and constant wave climate. Short term erosional or accretional charges (summer and winter beaches) around the mean equilibrium profile are minor perturbations generated by wave change. Contrasted against this is the continuous historic landward shift, controlled by two major parameters, (a) storm frequency and (b) rising sea level. For Long Island, the average number of tropical storms increased from 8/year to 10/year in a 70 year period (Dunnard Miller, 1960). El-Ashry (1971) suggested that the storm frequency increase has been the most important factor in erosion along U.S. shorelines.

The rise in sea level is well documented, (Schwartz, 1975; Hicks and Crosby 1974), showing that given a profile of equilibrium, as sea level rises, a volume of material is eroded from the upper beach face and deposited as an equal volume on the adjacent nearshore bottom, following the Per Brunn rule. Implicit in this mechanism is the net loss of sediments from the beach to offshore areas. This presumption may not be relevant to the south shore of Long Island, as barrier islands require a balanced sediment budget, a negative budget would result in the destruction of the barrier form. McCormick and Toscano (1980) have proposed a mechanism to allow for the long-term continuity of the Long Island barrier system and increasing drift to the west, (Fig. 2.16). The shoreface is conceived as a zone of aggradation and the ramp (flat gently sloping portion of a profile) as a zone of erosion toward the equilibrium profile, i.e. as sea level rises sediment is eroded from the ramp and transported landward to the shoreface. In order for equilibrium to be maintained, the entire profile must be shifted upward as well and landward.

FIG. 2.16


Mechanism for shoreline recession
EQUILIBRIUM PROFILE SHIFTED UPWARD AND LANDWARD
PROFILE RAISED VERTICALLY
area of accumulation
original outwash deposit slope
area of removal
area of accumulation
original equilibrium profile
area of removal

CHAPTER 3

CHAPTER 3

METHODOLOGY

3 (i) Surface Texture Analysis by S.E.M.

Surface textures important to environmental reconstruction, are discussed in 3 (iii), as the similarity between modern and ancient parameters is close, permitting environmental correlations to be made.

Past workers (e.g. Krinsley and Donahue, 1968) utilized surface textures to determine various sedimentary environments, based on the dictum that depositional history is reflected in the surface feature. Coch and Krinsley (1971) prodiced an assemblage of surface characteristics that were typical of glacial, beach and dune environments by assessing the relative importance of features and not just their presence. A semi-quantitative technique to identify certain microtextures was adopted by Setlow and Karpovich (1972, P.864), who stated that 'combinations of micro-textures, as indicated by quantitative analysis provides the best means of determining sediment palaeo-environments'.

Work in the 1980's has seen a revival of textural research, but due to the wide variety of approaches and terminology adopted, problems of methodology still exist. Currently the use of unknown grains is favoured for analysis but no standard acceptable methodology has evolved. Krinsley (Pers. Comm.) advocates the use of many photographs, while Bull (Pers. Comm.) favours the use of a feature checklist although there is still disagreement about many features i.e. meandering ridges (Grant, Pers. Comm.). Bull's (1981) checklist approach is utilized in this work but photographs were also taken to enhance analysis. Although many papers have investigated surface textures of grains from glacial, dune and fluvial environments, little or no S.E.M. work has been carried out on Barrier Island environments, possibly because a barrier environment is dominated by marine processes. These affect all other environmental aspects and tends to overprint other combinations of micro-textures unique to the different barrier environments, making discrimination between samples difficult.

Statistical analysis is employed, in keeping with present thinking (Bull, 1981) but caution is needed in interpretation. Krinsley and Marshall (1983, P.18) remarked, 'It cannot produce new insights unless the origin and evolution of a raw textural data are properly understood'.

3 (ii) Quartz Grain Samples

Quartz grain samples were examined representing the five nearshore barrier island environments, detailed in Chapter I. Brazilian crushed quartz and Kalahari sand samples were also analysed, to act as controls. One glacial lobe sample, (Appendix a)was also examined, to try to establish generic links with nearshore samples.

Preparation techniques of the grains for S.E.M. analysis were as outlined by Krinsley and Doornkamp (1973). 3 - 400 1.0 ϕ sized grains from each sample were prepared, in the following steps:

(1) Grains were boiled in dilute hydrochloric acid, washed with distilled water, then boiled in concentrated stannous chloride for ten minutes before washing in distilled water then left to dry.

(2) Each of the samples were viewed under the petrological microscope to choose unicrystalline grains, as polycrystalline grains may present complete surface features, as many depend on internal crystallographic structures, e.g. cleavage.

(3) 25 unicrystalline grains were then mounted onto an aluminium stub, in rows of 5. A blob of silver conductive paint was added to one corner, to allow numerical identification of individual grains. Before scanning, each individual grain was analysed by X-ray dispersive analyser to confirm a quartz origin. The grains were then sputter coated with 400 A^{o} of gold, to allow electron emission. 50 grains per sample were used. In the literature the number of grains studied for S.E.M. analysis has varied widely, with no real standard number being accepted. Hey et al (1971) quoted 35, Krinsley and Margolis (1971) 25; Tovey (1974) 28 - 30; Krinsley et al (1964) 30; Coch and Krinsley (1971)

argued that samples of 10 - 15 grains are sufficiently large to delineate the depositional environments of a single field sample. Examination of additional grains does not appear to affect interpretation materially. More recently the use of 10 - 15 grains to achieve results was reaffirmed by Krinsley (1983), 50 grains (2 stubs) were used in this work.

3 (iii) Surface Texture Analysis

Quartz grain surface textures have been used successfully as indicators of the environmental history of a sediment but the validity of specific examination techniques is still a matter of debate. Some workers (e.g. Margolis and Kennett, 1971; Bull, 1978) have developed the use of binary (presence or absence) data of surface features and this is the main method that will be used to discriminate between the near-shore barrier environments in this study.

The actual composition of variables in the checklist has been shown in the literature survey to be a matter of debate, with some workers failing to recognise features used by others. The checklist used is an amalgamation of several checklists (used by Bull, Morgan, Pers. Comm.) and 36 variables were used. Photographs were taken of features that were distinctive to individual samples, approximately two per sample. More than this tended to slow up analysis.

Each grain was initially analysed to x500, to determine general features such as shape, edge abrasion, and relief, then higher magnifications up to 5K were used to show chemical features, mechanical V's and scratches. As highlighted in the literature survey certain environments contain characteristic surface textures.

Mechanical V-shaped indentations (M.V's) (Inlet Plate 2[illegible]) were the most common feature noted on littoral grains. The amount of energy available in a specific environment is a major factor in determining the nature and size of the V's formed. Bull (Pers. Comm.) has also related the occurrence of M.V's. to grain angularity, more 'pointed' grains creating more M.V's. than rounded grains. In high energy littoral environments v-shaped patterns were irregularly orientated. Margolis and Krinsley (1971) found that mechanical V's were present on quartz sand grains from most subaqueous environments where applicable grain to grain impacts occur, with more than one 'V' resulting from a single collision.

Conchoidal fractures of varying dimensions and abundance have been observed on grains from many environments but are especially prevalent on grains from glacial environments. When contact occurs with uniform compression between two grains, many types of conchoidal breakage patterns may be produced, ranging from disc shaped to irregular (Overwash, Plate 8). They may be produced in the subaqueous environment but are not common. On aeolian grains they tend to be disc-shaped and are typically larger than those on either glacial or subaqueous grains. Where large conchoidal fractures amalgamate large flat areas result (Bull, Pers. Comm.).

Upturned cleavage plates are a series of thin parallel plates usually orientated at some angle to the grain surface. The plates unaffected by solution and precipitation are jagged and irregular in height and generally broken on top. Large aeolian grains exhibit this feature. Usually plates are concentrated on the edges of the grains. If abrasion continues for a long period, the grain will approach a sphere (Dune, Plate 4).

High relief (F.T.D., Plate I) when compared to grains from littoral and aeolian environments, is a characteristic of glacial textures and is related to the relative larger size of particles and large amount of energy available for grinding (Krinsley and Donahue, 1968). Large breakage blocks (F.T.D., Plate 3) are also characteristic of glacial origin.

Graded arcs occur in concentric series, with a gradation in size. They possibly represent percussion features and thus are a subvariety of conchoidal fracture. Coastal dune sands have been found to contain arcs. Other features such as striations, large variation in size of conchoidal fractures are also thought to be diagnostic of glacial origin.

Features of chemical origin consist of various types of etch features and overgrowths (F.T.D., Plate 12). A major type of etching, crystallographically orientated 'V' pits are commonly found on marine sands (Cater, 1984, Inlet, Plate 12). Chemical features can be found in varying degrees on quartz grains from every environment, modifying and obliterating previous existing mechanical features. Chemical action is prevalent in the aeolian environment, often subduing or completly covering cleavage plates (Dune, Plate 4). Grains from coastal dunes have been observed which contain only beach features, where wind force is small and surf abrasion great. Smaller sand grains, given lack of chemical action reflect their previous transport cycle and are generally angular (Dune, Plate 5), and this may persist even though a previous chemical episode has taken place. The dune results, indicated a combination of angular and subrounded grains (Dune, Plate 4 and Plate 8).

Sand grains from beaches, with low wave activity, exhibit orientated etch pits (Beach, Plate14) attributed to the solution of quartz by sea water and are surface expressions of crystal defects. Grains from beaches with moderate wave energy show a combination of chemical etching and mechanical features.

In all environmental discrimination it should be emphasised that no single key surface feature is deterministic, a multiplicity of features must be used.

3 (iv) Statistical Analysis

(1) Discriminant analysis.

The aim of discriminant analysis is to examine how far it is possible to distinguish between members of various groups on the basis of observations made upon them. The data consist of the values of a set of random variables x......xp on n + 1 individuals which are divided into g (known) groups. The analysis provides:

(a) Tests of significance for differences in the values of the x's between the groups;

(b) Allocation rules, for identifying further individuals as belonging to one of the groups on the basis of the values of the x's. These rules are expressed in terms of discriminant functions (Marriot, 1974);

(c) Estimates of the probility of correct allocation, using the rules that have been derived.

As such, discriminant analysis is an extension to multivariate observations of the ordinary analysis of variance within and between groups. If an observation x is derived from a multivariate normal distribution with dispersion matrix A and mean $\bar{x}$, the likelihood of x, or the probability density at x, is proportional to:

$$\exp - \tfrac{1}{2} (x - \bar{x}) A (x - \bar{x}).$$

Given two such distributions with estimated means $\bar{x}_A$ and $\bar{x}_B$ and estimated matrix V, it is natural to assign x to whichever has the higher likelihood. The difference between the log likelihood is estimated as:

$$Y = - \tfrac{1}{2} (x - \bar{x}_A) ' W^{-1} (x - \bar{x}_A) + \tfrac{1}{2} (x - \bar{x}_B) ' W^{-1} (x - \bar{x}_B)$$

This reduces to:

$$Y = (x - \bar{x}) ' W^{-1} d$$

Where $\bar{x} = \tfrac{1}{2} (\bar{x}_A + \bar{x}_B)$, $d = \bar{x}_A - \bar{x}_B$. This is a linear function of x, positive when the likelihood of x is greater for group A, and negative when it is greater for B and is called a linear discriminant function between the groups, and gives immediately the allocation rule: If Y˚0, assign x to A, if Y˚0 assign x to B.

The success of a discriminant function analysis can be judged by estimating the proportion of the population which would be correctly classified. The estimate may be based either on the proportion of the assumed multivariate normal distribution on either side of the plane defined by the discriminant function, or on the proportion of the sample actually on either side of the plane. The latter method involves simply counting the actual members of the sample that would have been misclassified by using the allocation rule derived. This does give a biased estimate, as the rule is based on the particular sample, and is likely on the whole to give better results for it than for other samples, or for the population as a whole, (Press and Wilson, 1978).

Tables 5.1 - 5.xiv show discriminant results obtained from discriminant analysis of the checklist results, in binary form. Discriminant analysis, in addition to distinguishing between two groups, is used to distinguish between all seven groups.

CHAPTER 4

CHAPTER 4

Literature Survey

With reference to surface texture determination of sand grains by the scanning electron microscope "The state of the art should have advanced in the realm of feature origin occurrence and a whole host of other areas", Krinsley and Marshall, P.17, 1983).

Historically, Sorby (1880) was the first to emphasise the significance of the surface texture of sand grains, noting a 'frosted' appearance in some grains. Much later, Caill.eux (1943) determined four different types of grains:

(1) Not abraded grains.

(2) Well rounded shiny grains.

(3) Well rounded frosted grains.

(4) Rounded, dirty grains.

Also noted was the amount of well rounded 'frosted' grains in a sample increased proportionally with the intensity of wind action to which the grain had been subjected. Frosting was thought to be the result of small percussion marks caused by grain to grain impact during wind transportation. In contrast water transport produced a shiny lustre on the grain surface, possibly due to salt and clay particles, with water, forming a polishing paste.

Later work by Kuenon and Perdok (1962) concluded that frosting was not the result of mechanical action but of chemical origin, which was also used to account for the shiny lustre found on the particles. But why study sand grain textures? Miller and Ocean (P.13, 1955) considered that all properties of contemporary environments of sedimentation could be divided into five groups, the third of which included all properties which are the same in both modern sediments and lithology. It is into this third group that surface textures primarily fall and it was this type of measure that was useful in environmental reconstruction especially if the parameters are chosen carefully and its origins understood (Evans, 1983). According to Krinsley (P.113, 1983) "This is one of the major reasons why the origin of sand grain textures should be studied in great detail, knowledge of the physical and chemical manner in which features originate could be directly related back to lithology".

Textural analysis of sand grain surfaces began in the early 60's when three classic papers were published (Biderman, 1961; Porter, 1962; Krinsley and Takahashi in 1964) describing the relationship between quartz sand grain surfaces and roughness or texture, viewed with the Transmission Electron Microscope (T.E.M.). Grains were studied from a range of known environments (aeolian, beach, glacial) and relationships established between observed groups of surface textures and the environment. Krinsley and Takahashi (1964) compared surface textures of quartz grains from known modern environments to textures produced artificially from sand blasting, shaking table, ball mill and pressure grinding experiments. Correlation between natural and artificial specimens were established and unique textures for each environment determined.

T.E.M. was also used in a study of sand grain transport along the Atlantic shore of Long Island (Krinsley et al 1964), close to the present study area. They attempted to determine:

(1) Whether elements of the Montauk Hill could be identified in beach sands to the west of Montauk Point?

(2) If this was possible, what surface textural changes resulted from beach action?

(3) From how great a distance along the beach could characteristic glacial features exist?

The samples from the beach at Montauk Point, where the till is being eroded by waves, exhibited textural characteristics of glacial origin, including a series of conchoidal fractures, arc shaped steps and extensive relief. Mechanical V's were found which are indicative of the fluvial environment. To the west, glacial characteristics were increasingly replaced by 'V' shaped beach textures. Surface textures resulting from aeolian action were observed on the dune grains but few aeolian textures were observed on beach grains, implying little feedback of dune sands to the beach environment.

Throughout the 1960's various workers, Krinsley and Funnel (1965), Biederman (1961), Krinsley and Donahue (1968), Krinsley and Newman (1965), used the T.E.M. to investigate grains of known environments. The appearance of the scanning electron microscope (S.E.M.) revolutionised textural analysis, providing greater accuracy and simplification. T.E.M. was made virtually redundant and in Krinsley and Bull's words "of dubious value or relevance to modern work" (Pers. Comm.).

The S.E.M. overcame many problems, i.e. no need for replication thus eliminating distortion and artifacts, and provided a continuous magnification from 60 - 100,000 x, permitting a smaller area of the grain to be studied. The examination period was speeded up, as 300grains at a time could be studied.

The advent of the S.E.M. led to a number of papers being written using the technique for environmental interpretation. Further developments enabled far more subtle environmental discrimination. Krinsley and Donahue (1968), and Lucchi and Cara (1968) extended knowledge of the textural assemblage of desert sand grains. Krinsley and Donahue (1968) succinctly reviewed the state of the art of producing a summary table, using over 4,000 quartz grain surfaces and establishing specific differences in the environment of transportation and deposition. This paper remains an important influence in the interpretive procedures of the technique and provided clarity within a partly contradictory subject.

Early 1970's papers (Margolis and Kennett,1971, Krinsley and Donahue, 1968), used the increas d potential of the S.E.M. to apply quantitative measurements to sand grains. Krinsley and Donahue (1968) measured mechanical 'V' density per μ^2 and related to results to the distance the grains travelled to Montauk Point.

Margolis and Kennett (1971) further expanded this quantitative approach. Setlow and Karpovich (1972) employed a semi-quantitative technique to discriminate between mechanical breakage textures from a littoral environment and textures produced by glacial processes. The degree of development and area of development of 22 separate micro-textures were established for each grain. The degree of development of each individual feature was determined and assigned a numerical value.

The semi-quantitive measurements of grain features decreased during the 1970's although more recent studies stress the importance of returning to some form of numerical analysis (e.g. Le Riboult, 1975). Since a large number of grains were usually examined and numerous textures are to be found on grains, the subject should lend itself to statistical analysis (Krinsley and Marshall, 1983) but it is pointed out that although the use of statistical analysis is a definite direction for future work, origin and evolution of textural data must be appreciated.

Recently a multiplicity of related papers have been published over a short period by only a few people and many of these failed to bring about any significant advances. Exceptions to this were Margolis and Krinsley (1971) who presented for the first time, the physical and chemical factors that produce micro-features in quartz and were able to summarise diagrammatically, 22 major surface textures, in relation to their relative abundance in the world's major environments. Margolis and Krinsley (1971) reviewed the use of S.E.M. analysis of surface features and pointed out that reconstruction of environments of transportation and deposition has enjoyed varied success. Also highlighted was the dearth of publications on the mechanisms for the diversity of micro-features.

The 80's have seen a reinforcement of the trend towards theoretical and experimental production of surface features, the so-called 'second generation' analysis (Bull, Pers. Comm.). Experimental surface texture production is contradicting and confirming many of the more vague assumptions, especially in the realm of energy levels, in the production of surface features.

More succinct work is appearing (Cater. 1984, Williams et al 1985) where a whole range of evidence (e.g. Superimposition of features, areal extent of features and graphical evidence) is given to delineate sediment textural history. Culver et al (1983) carried out a statistical investigation on environmental discrimination based on grain surface texture. The relative abundance of thirty-two surface features from eight coded samples were noted by five S.E.M. workers. Data reduced to binary form was subjected to canonical variate analysis which discriminated clearly between all samples. Thirteen variables were important in distinguishing between the sample, indicating that no single key surface feature would allow rapid environmental discrimination. The conclusion affirmed the use of a checklist approach, which is a reliable and statistically valid means of discriminating between samples from different environments. Culver et al (1983) pinpointed possible operator variance, which although considerable in the scoring of individual surface features was negligible in discrimination of samples, based on analysis of binary data.

Fourier analysis of quartz grain shapes across the shelf and adjacent beach-littoral system off Long Island has revealed the presence of two shape types (Reister et al, 1982). Type I grains were mature sand, having undergone several cycles of abrasion, in contrast Type 2 sand had not been subjected to prolonged abrasion. This line of evidence is investigated in the results section (Chapter 5).

CHAPTER 5

CHAPTER 5

Results and Discussion

5 (i) Statistical Results

(a) Introduction.

Discriminant analysis is a statistical technique in which linear combinations of variables are used to distinguish between two or more categories of cases, to predict into which category or group a case falls. (see Methodology, Chapter 3).

Initially all 36 variables (Table 5.(iv)) were used for discrimination, utilizing stepwise analysis. This entails the determination of a set of variables that maximises the discriminating power. Five methods can be used to determine the most important variables. For this analysis the Mahalanobis D^2 method, the variable that maximises the Mahalanobis distance was used. All variables were tested for removal on the basis of partial F values (see Methodology, Chapter 3).

(b) Multigroup analysis

Two population sizes were used, 25 and 50 grains (Tables 5.1 and 5.11) for the seven samples. It was apparent that 50 grain populations gave superior results (66% to 37.14% respectively). Table 5.11 shows how effective the analysis was in discriminating between control and nearshore samples. The latter results ranged from 44% (Inlet) to 68% (Beach). Inlet samples contained a major component misclassified as flood tidal delta (20%). In process terms this was expected, for a portion of Inlet material is transported through an Inlet for deposition in the form of a tidal delta. Similarly a portion of beach sample (18%) will be contained in a dune sample. In an onshore-response model, water may flow up to and over the dune scarp, eroding material from the beach and dune, depositing it over the dune crest. Additionally there must be an onshore/offshore component, of aeolian transport of sediment in this environment.

Table 5.111 shows discrimination only between nearshore samples, without control samples. Apart from Inlet samples, all percentage classification decreased. The beach sample was again highest, although 0% of the beach sample was included in the F.T.D. sample in 7 group discrimination, 12% was included when controls were removed. Obviously complex associations of variables have taken place with control removal. In almost all cases there was a substantial degree of misclassification, reiterating the belief that homogenization of sediments has reduced the effectiveness of discrimination, especially where large numbers of groups are used.

Table 5.IV shows the variables used in 5 group analysis. Thirteen variables were important for the 5 group discrimination. Significantly most were mechanically derived features, only irregular solution surface being of chemical origin. Results confirmed earlier findings, (Scheider, 1981 ; Culver et al, 1983, a. b.), that there are no simple diagnostic features for any particular environmental reconstruction. Relationships between the statistical model and visual evidence is shown on the checklist (Table 5xv). This shows percentage occurrence of features and percentage differences between all 5 groups, and gives an indication of prominant variables. Results showed that most of the variables used in discriminant analysis, had greater than 20% differences. More complex criteria were used for discrimination, but percentage differences confirm the accuracy of the statistical model. Chemical features were scarce but this may be an indication of checklist bias, which restricted chemical features, as they are dubious value for reconstruction (Bull, 1981). Most noticable variables were the larger scale breakage features including blocky depressions, large flat areas, M.V's, indicating the fluvial glacial nature of the grains.

(c) Two group analysis

Discriminant analysis can also be used to discriminate between two groups only. Tables 5.v - 5.xiv show results obtained for this analysis.

(c) (i) F.T.D. -vs- Overwash (Table 5.v)

This gave an 81% overall correct classification, an indication that the analysis performs better for 2 group discrimination than 5 group analysis. The majority of selected variables were mechanical, including relief, conchoidal fracture and blocky topography. Angularity was also included, a rare occurrence in the overall analysis but a reasonable indication of the presence of the glacial source, which provided all nearshore environments with an angular component and similar primary characteristics. Sequential passage through onshore sinks then superimposed differing textural patterns onto the grains. From it should be noted that severe edge abrasion did not feature yet there was substantial difference in percentage terms, highlighting the need for caution.

(ii) F.T.D. -vs) Dune (Table 5.vi)

This gave an 85% correct classification. The stepwise analysis has altered the variables, used in (c) (i), indicating that no set of variables was diagnostic of all samples. However, there were common trends. Relief again is a discriminating factor coupled with mechanical V's, sickle pits and cracks, the latter found in large percentages on the dune samples.

(iii) F.T.D. -vs- Inlet (Table 5.vii)

This produced a lower correct classification (72%) especially for the flood tidal delta samples. A large F.T.D. component has been classified as Inlet (42%) while only 14% of Inlet samples were misclassified as F.T.D. This can be explained in the process model (see Chapter 2, section (ii)). Possibly the F.T.D. processes imposed a certain textural assemblage which distinguished a portion of the grains from the Inlet sample.

(iv) F.T.D. -vs- Beach (Table 5.viii)

Again a reasonable correct classification (85%). The variables used indicated more classic littoral features, such as blocky textures, sickle pits and isolated V-shaped blocks. The higher classification possibly indicated the lack of interchange between the two environments, producing more distinguishing features.

(v) Beach -vs- Inlet (Table 5.ix)

A reduced correct classification (72%) was recorded for Inlet samples, due to the misclassification of 28% in the beach sample. This may represent the proportion of Inlet sample that is removed from the beach front itself. Edge abrasion, both severe and moderate, discriminated for the first time, an indication of the reduced use of edge abrasion in sediment discrimination. Chemically produced V's were more prevalent on Inlet samples due to the prolonged quiessence period.

(vi) Beach -vs- Dune (Table 5.x)

For this analysis M.V's were selected as the major discriminating variable indicating the reduced influence of subaqueous processes on the dune sample. Blocky topography again appeared, highlighting the littoral influence on all samples.

(vii) Beach -vs- Overwash (Table 5.xi)

Both samples produced acceptable correct results (85%). The variables used were all mechanical including large flat areas, sickle pits and relief. Results indicated that although the two samples may be genetically linked they have their own characteristics that can distinguish between them and are not so closely linked as other near-shore sediments, e.g. flood tidal delta and inlet.

(viii) Inlet -vs- Dune (Table 5.xii)

From the table it can be seen that a large Inlet component has been assigned to the dune sample. In process terms this is more difficult to understand than say the F.T.D./Inlet results. One assumption is that the 'Dune Component' is integrated into the Inlet sample when the Inlet breaks through the dune line, eroding and encapsulating dune sediments.

(ix) Inlet -vs- Overwash (Table 5.xiii)

These again produced reasonable results with no apparent large scale component in either sample.

(x) Dune -vs- Overwash (Table 5.xiv)

The overall correct classification (94%) is the highest for all samples, in the two group analysis. 42% of the Dune sample component is incorporated into the overwash sample when overwash breaks through the dune line, the resulting washover sediment, being a mixture of dune and washover material.

TABLE 5.1 25 Grains

Actual Group	No of Cases	Predicted Group Membership					Controls	
		F.T.D.I	Beach 2	Inlet 3	Dune 4	Overwash 5	K. Desert	B.C.Q.
Group 1	25	4 16%	1 4%	12 48%	6 24%	2 8%	0 0%	0 0%
Group 2	25	1 4%	4 16%	8 32%	7 28%	3 12%	2 8%	0 0%
Group 3	25	5 20%	1 4%	13 52%	2 8%	4 16%	0 0%	0 0%
Group 4	25	0 0%	2 8%	2 8%	11 44%	4 16%	5 20%	1 4%
Group 5	25	1 4%	4 16%	9 36%	6 24%	1 4%	4 16%	0 0%
Group 6	25	0 0%	0 0%	0 0%	5 20%	2 8%	11 44%	7 28%
Group 7	25	0 0%	0 0%	0 0%	0 0%	0 0%	4 16%	21 84%

ercentage of 'grouped' cases correctly classified; 37.14%

TABLE 5.ii   50 Grains

Actual Group	No. of Cases	Predicted Group Membership F.T.D. 1	Beach 2	Inlet 3	Dune 4	Overwash 5	K. Desert	B.Q.C.
Group 1	50	25 50%	4 8%	6 12%	4 8%	8 16%	1 2%	2 4%
Group 2	50	0 0%	34 68%	4 8%	9 18%	1 2%	2 4%	0 0%
Group 3	50	10 20%	6 12%	22 44%	5 10%	3 6%	1 2%	3 6%
Group 4	50	2 4%	3 6%	7 14%	29 58%	2 4%	5 10%	2 4%
Group 5	50	2 4%	2 4%	3 6%	4 8%	31 62%	2 4%	6 12%
Group 6	50	0 0%	1 2%	1 2%	4 8%	1 2%	43 86%	0 0%
Group 7	50	0 0%	0 0%	0 0%	2 4%	1 2%	0 0%	47 94%

Percentage of 'Grouped' Cases Correctly Classified: 66.00%

TABLE 5.iii 50 Grains

Actual Group	No. of Cases	Predicted Group Membership F.T.D. 1	Beach 2	Inlet 3	Dune 4	Overwash 5
Group 1	50	25 50%	3 6%	10 20%	1 2%	11 22%
Group 2	50	6 12%	31 62%	4 8%	7 14%	2 4%
Group 3	50	9 18%	6 12%	24 48%	7 14%	4 8%
Group 4	50	8 16%	4 8%	9 18%	25 50%	4 8%
Group 5	50	8% 16%	4 8%	4 8%	5 10%	29 58%
Ungrouped Cases	100	19 19%	6 6%	15 15%	43 43%	17 17%

Percentage of 'Grouped' Cases Correctly Classified: 53.60%

TABLE 5.iv

Step	Action	Vars In	Wilks' Lambda	Sig.	Minimum D Squared	Sig.	Between Groups F.T.D.	Beach
1	F13 Convex up	1	0.929314	0.0012	0.19732E-01	0.4831	1	2
2	F25 P.S.S.	2	0.852409	0.0000	0.88126E-01	0.3355	1	5
3	F9 Top.neg.Med.Rel.	3	0.763035	0.0000	0.32798	0.0916	3	4
4	F32 S.Capping Layer	4	0.749356	0.0000	0.43672	0.0315	3	4
5	F17 Cracks	5	0.695235	0.0000	0.52021	0.0281	3	4
6	F22 Isol.L.V. Blocks	6	0.661247	0.0000	0.56019	0.0364	3	4
7	F28 M.V's.	7	0.602334	0.0000	0.67418	0.0245	1	5
8	F24 L.F.A.	8	0.559525	0.0000	0.73157	0.0267	1	3
9	F23 L. Blocks	9	0.519679	0.0000	0.84300	0.0189	1	3
10	F30 Sickle Pits	10	0.480060	0.0000	0.87613	0.0245	1	3
11	F29 Irreg. Pits	11	0.458708	0.0000	0.98011	0.0353	1	3
12	F34 Chem. V's.	12	0.437982	0.0000	1.1657	0.0081	1	3
13	F21 Block dep.	13	0.418178	0.0000	1.1669	0.0132	1	3

TABLE 5.v F.T.D. -vs- Overwash

Actual Group	No. of Cases	Predicted Group Membership F.T.D. 1	Overwash 5
Group 1	50	42 84%	8 16%
Group 5	50	11 22%	39 78%
Ungrouped Cases	250	149 59.6%	101 40.4%

Percent of 'Grouped' Cases Correctly Classified: 81.00%

Step	Action Entered Removed	Vars In	Wilks' Lambda	Sig.	Minimum D Squared	Sig.	Between Groups	
1	F24 L.Flat Areas	1	0.909091	0.0023	0.39200	0.0023	1	5
2	F1 Angularity	2	0.826293	0.0001	0.82408	0.0001	1	5
3	F15 Con + Arcuate C.F.'s	3	0.783558	0.0000	1.0828	0.0000	1	5
4	F3 High Top Pos. Relief	4	0.747658	0.0000	1.3230	0.0000	1	5
5	F2 V.High Top Pos. Relief	5	0.701675	0.0000	1.6666	0.0000	1	5
6	F29 Irregular Pits	6	0.661938	0.0000	2.0020	0.0000	1	5
7	F22 Isol.L.V-Shaped Blocks	7	0.618762	0.0000	2.4152	0.0000	1	5

TABLE 5.vi F.T.D. -vs- Dune

Actual Group	No. of Cases	Predicted Group Membership F.T.D. 1	Dune 4
Group 1	50	43 86%	7 14%
Group 4	50	8 16%	42 84%
Ungrouped Cases	250	126 50.4%	124 49.6%

Percent of 'Grouped' Cases Correctly Classified: 85.00%

Step	Action Entered Removed	Vars In	Wilks' Lambda	Sig.	Minimum D Squared	Sig.	Between Groups	
1	F28 M.V's	1	0.870192	0.0002	0.58475	0.0002	1	4
2	F30 Sickle Pits	2	0.779241	0.0000	1.1105	0.0000	1	4
3	F9 Med. Top Neg. Relief	3	0.703478	0.0000	1.6523	0.0000	1	4
4	F21 L.Irreg.Block Dep.	4	0.619742	0.0000	2.4052	0.0000	1	4
5	F12 Concave up C.F.'s	5	0.568756	0.0000	2.9722	0.0000	1	4
6	F17 Cracks	6	0.536610	0.0000	3.3851	0.0000	1	4
7	F10 Low Top Neg. Relief	7	0.501389	0.0000	3.8983	0.0000	1	4

TABLE 5.vii F.T.D. -vs- Inlet

Actual Group	No. of Cases	Predicted Group Membership F.T.D. I	Inlet 3
Group 1	50	29 58%	21 42%
Group 3	50	7 14%	43 86%
Ungrouped Cases	250	84 33.6%	166 66.4%

Percent of 'Grouped' Cases Correctly Classified: 72%

Step	Action Entered Removed	Vars In	Wilks' Lambda	Sig.	Minimum D Squared	Sig.	Between Groups	
1	F.13 Convex up.Conc.Fracs	1	0.927964	0.0066	0.30840	0.0066	1	3
2	F.9 Med.Top.Neg. Relief	2	0.873999	0.0015	0.56513	0.0015	1	3
3	F.12 Concave up. C.F.'s	3	0.830151	0.0004	0.80203	0.0004	1	3
4	F.22 Isol.L.V-Shaped Blocks	4	0.797005	0.0002	0.99841	0.0002	1	3
5	F.24 L.Flat Areas	5	0.755834	0.0001	1.2663	0.0001	1	3

TABLE 5.viii F.T.D. -vs- Beach

Actual Group	No. of Cases	Predicted Group Membership F.T.D. 1	Beach 2
Group 1	50	42 84%	8 16%
Group 2	50	7 14%	43 86%
Ungrouped Cases	250	168 67.2%	82 32.8%

Percent of 'Grouped' Cases Correctly Classified: 85%

Step	Action Entered Removed	Vars In	Wilks' Lambda	Sig.	Minimum D Squared	Sig.	Between Groups	
1	F23 L. Blocks	1	0.859375	0.0001	0.64145	0.0001	1	2
2	F25 P. Straight Scratches	2	0.746034	0.0000	1.3345	0.0000	1	2
3	F30 Sickle Pits	3	0.690220	0.0000	1.7594	0.0000	1	2
4	F9 Med.Top.Neg.Relief	4	0.649619	0.0000	2.1143	0.0000	1	2
5	F22 Isol.L.V-shaped	5	0.616696	0.0000	2.4365	0.0000	1	2
6	F6 Smooth Top.Pos.Relief	6	0.585993	0.0000	2.7695	0.0000	1	2

TABLE 5.ix Beach -vs- Inlet

Actual Group	No. of Cases	Predicted Group Membership Beach 2	Inlet 3
Group 2	50	42 84%	8 16%
Group 3	50	14 28%	36 72%
Ungrouped Cases	250	112 44.8%	138 55.2%

Percent of 'Grouped' Cases Correctly Classified: 78%

Step	Action	Vars In	Wilks' Lambda	Sig.	Minimum D Squared	Sig.	Between Groups	
1	F25 Parallel Straight Scratches	1	0.757016	0.0000	1.2582	0.0000	2	3
2	F23 Isol. Blocks	2	0.694285	0.0000	1.7261	0.0000	2	3
3	F18 Severe Edge Abrasion	3	0.660858	0.0000	2.0117	0.0000	2	3
4	F19 Mod.Edge Abrasion	4	0.632767	0.0000	2.2750	0.0000	2	3
5	F22 Isol.L.V-Shaped Blocks	5	0.597034	0.0000	2.6458	0.0000	2	3
6	F34 Chem.Orient. V's.	6	0.606485	0.0000	2.5435	0.0000	2	3

TABLE 5.x Beach -vs- Dune

Actual Group	No. of Cases	Predicted Group Membership Beach 2	Dune 4
Group 2	50	42 84%	8 16%
Group 4	50	11 22%	39 78%
Ungrouped Cases	250	93 37.2%	157 62.8%

Percent of 'Grouped' Cases Correctly Classified: 81%

Step	Action Entered Removed	Vars In	Wilks' Lambda	Sig.	Minimum D Squared	Sig.	Between Groups	
1	F28 M.V's.	1	0.855078	0.0001	0.66438	0.0001	2	4
2	F23 Large Blocks	2	0.754601	0.0000	1.2748	0.0000	2	4
3	F35 L.Isol.Chem.V's.	3	0.707239	0.0000	1.6227	0.0000	2	4
4	F9 Med.Top.Neg. Relief	4	0.660250	0.0000	2.0171	0.0000	2	4
5	F24 L.Flat Areas	5	0.630885	0.0000	2.2935	0.0000	2	4
6	F16 Radiating Steps	6	0.604709	0.0000	2.5625	0.0000	2	4

TABLE 5.xi Beach -vs- Overwash

Actual Group	No. of Cases	Predicted Group Membership Beach 2	Overwash 5
Group 2	50	42 84%	8 16%
Group 5	50	7 14%	43 86%
Ungrouped Cases	250	112 44.8%	138 55.2%

Percent of 'Grouped' Cases Correctly Classified: 85%

Step	Action Entered Removed	Vars In	Wilks' Lambda	Sig.	Minimum D Dquared	Sig.	Between Groups	
1	F24 L.Flat Areas	1	0.0840000	0.0000	0.74667	0.0000	2	5
2	F30 Sickle Pits	2	0.722798	0.0000	1.5034	0.0000	2	5
3	F17 Cracks	3	0.652173	0.0000	2.0907	0.0000	2	5
4	F5 Low Relief Top.Pos.Area	4	0.589298	0.0000	2.7320	0.0000	2	5
5	F13 Convex up. C.F's.	5	0.559979	0.0000	3.0803	0.0000	2	5
6	F26 Curved Scratches	6	0.527336	0.0000	3.5136	0.0000	2	5
7	F23 Large Blocks	7	0.499684	0.0000	3.9250	0.0000	2	5
8	F25 Parallel Straight Scratches	8	0.478692	0.0000	4.2690	0.0000	2	5
9	F6 Smooth Top.Pos. Areas	9	0.457234	0.0000	4.6533	0.0000	2	5

TABLE 5.xii   Inlet -vs- Dune

Actual Group	No. of Cases	Predicted Group Membership Inlet 3	Dune 4
Group 3	50	34 68%	16 32%
Group 4	50	10 20%	40 80%
Ungrouped Cases	250	111 44.4%	139 56.6%

Percent of 'Grouped' Cases Correctly Classified: 74%

Step	Action Entered Removed	Vars In	Wilks' Lambda	Sig.	Minimum D Squared	Sig.	Between Groups	
1	F28 M.V.'s	1	0.855078	0.0001	0.66438	0.0001	3	4
2	F36 U. Plates	2	0.783449	0.0000	1.0835	0.0000	3	4
3	F1 Angularity	3	0.715405	0.0000	1.5594	0.0000	3	4
4	F17 Cracks	4	0.685019	0.0000	1.8025	0.0000	3	4

TABLE 5.xiii Inlet -vs- Overwash

Actual Group	No. of Cases	Predicted Group Membership Inlet 3	Overwash 5
Group 3	50	41 82%	9 18%
Group 5	50	9 18%	41 82%
Ungrouped Cases	250	129 51.6%	121 48.4%

Percent of 'Grouped' Cases Correctly Classified: 82%

Step	Action Entered Removed	Vars In	Wilks' Lambda	Sig.	Minimum D Squared	Sig.	Between Groups	
1	F13 Convex up C.F's.	1	0.853374	0.0001	0.67353	0.0001	3	5
2	F29 Irreg. Pits	2	0.795551	0.0000	1.0074	0.0000	3	5
3	F32 Smooth Capping Layer	3	0.725670	0.0000	1.4819	0.0000	3	5
4	F24 L.F. Areas	4	0.662335	0.0000	1.9985	0.0000	3	5
5	F34 Chem.Orien.V's.	5	0.619872	0.0000	2.4039	0.0000	3	5
6	F18 Severe Edge Abrasion	6	0.592352	0.0000	2.6977	0.0000	3	5

TABLE 5.xiv. **Dune** -vs- Overwash

Actual Group	No. of Cases	Predicted Group Membership Dune 4	Overwash 5
Group 4	50	29 58%	21 42%
Group 5	50	3 6%	47 94%
Ungrouped Cases	250	102 40.8%	148 59.2%

Percent of 'Grouped' Cases Correctly Classified: 76%

Step	Action Entered Removed	Vars In	Wilks' Lambda	Sig.	Minimum D Squared	Sig.	Between Groups	
1	F30 Sickle Pits	1	0.864890	0.0002	0.61237	0.0002	4	5
2	F17 Cracks	2	0.760835	0.0000	1.2322	0.0000	4	5
3	F28 M.V's.	3	0.683903	0.0000	1.8118	0.0000	4	5
4	F13 Convex up. C.F.'s.	4	0.624023	0.0000	2.3618	0.0000	4	5

(d) Overall Summary

The two group analysis proved more successful than multi-group analysis. The former highlighted greater areas of sediment interchange particularly F.T.D., Inlet and Dune/Overwash. The overall classification of 80% is lower than results obtained by Culver (1983) in a similar analysis of contrasting environments. This is wholly due to the inherent similarity between them. The discrimination of unlike samples e.g. Brazilian crushed quartz (See Table 5.i) demonstrated that discriminant analysis can be successful.

5 (ii) Visual Results

Visual results for nearshore samples (in %) are given in Table 5.xv, Fig. 5(i) gives a diagrammatic form.

5 (ii) (a) Beach

Beach results indicate a predominantly angular grain shape. As in other samples a 'rounded' component (20%) is included. Topographically positive relief was generally high - medium. Topographically negative relief medium - low. Conchoidal fractures both large and small were common, but in contrast to the other nearshore samples large flat areas were reduced (30%). This may be due to increased surface abrasion during surf action obliterating these areas. Cracks were found in greater percentages (76%) than F.T.D. (46%), Inlet (56%), and Overwash (40%). This could be a resült of increased energy found in the Beach regime producing cracks then ultimatly grain breakage. Edge abrasion was severe to moderate, similar to other samples. Isolated large 'V' shaped blocks and large blocks were markedly increased (62% and 52% respectively), (see Plate 5). M.V's as on all nearshore samples was high (72%). Irregular solution surface/precipitation was lower than all samples except F.T.D., and reflects increased surf action. Chemical orientated V's were found infrequently (18%).

Beach results were in keeping with other workers' results for glacial - Fluvial grains (Margolis and Krinsley 1971)

(b) Inlet

As Inlet sediments are characterised by mixed sediments with components from beach, nearshore and lagoonal environments, homogenization of sediments is to be expected. (Chapter 2).

Topographically positive relief was predominantly medium to high (48% and 36%), topographically negative relief generally low (52%). As in all nearshore samples large and small scale conchoidal fractures were common. Edge abrasion was severe to moderate (50% and 42%), whilst isolated large 'V' shaped blocks were prominant (42%). Large flat areas, another common nearshore texture, were common (54%) indicating the effect of large scale conchoidal fracture. Mechanical 'V's', as elsewhere were ubiquitous. Irregular solution/precipitation surfaces were a noticable chemical feature (70%).

Table(xv)

CHECKLIST %		FTD	INLET	OVW.	DUNE	BEACH	% DIFF.
1	ANGULAR/ ROUNDED	78/12	80/20	62/34	71/29	76/20	6·4
2	V.HIGH RELIEF	0	4	6	0	2	6·4
3	HIGH RELIEF	30	36	42	25·5	28	16·4
4	MEDIUM RELIEF TOP.POS.AREAS	50	48	42	47	44	7·8
5	LOW RELIEF	12	12	6	25	20	20·4
6	SMOOTH	0	0	0	5	4	5·6
7	V.HIGH RELIEF	0	0	0	0	0	0
8	HIGH RELIEF	0	2	2	0	2	2·4
9	MEDIUM RELIEF TOP.NEG.AREAS	38	20	16	10·5	34	27·1
10	LOW RELIEF	42	52	48·5	57	42	16·6
11	SMOOTH	14	26	22	34·5	16	20·4
12	CONCAVE UP	46·5	30	54	29	36	25·4
13	CONVEX UP	32	12	44	19	26	30·8
14	DISH SHAPED CONCHOIDAL FRACS.	16	28	12	20·5	16	14·6
15	CON.FRACS.& ARCUATE STEPS	20	10	4	2·5	8	16·4
16	RADIATING STEPS	22	30	20·5	13·5	24	14·6
17	CRACKS	46	56	40	83	76	46·4
18	SEVERE EDGE ABRASION	48	50	34	31	42	20·8
19	MODERATE EDGE ABRASION	40	42	38·5	50	38	11
20	MILD EDGE ABRASION	6	8	14	19	10	12·8
21	L.IRREGULAR BLOCKY DEPRESSION	16	18	15	28	32	27
22	ISOL.L.V.SHAPED BLOCKS	28	42	44	53	62	31·6
23	L.BLOCKS	18	26	22	19·5	52	29·8
24	L.FLAT AREAS	40	54	70	64	30	41·6
25	PARALLEL STRAIGHT SCRATCHES	4	4	2	16	24	22·4
26	CURVED SCRATCHES	30	30	25	16	8	23·2
27	STRAIGHT SCRATCHES	16	26	14	29	36	22·8
28	M.V.s	70	74	62	37·5	72	33·2
29	IRREGULAR PITS	48·5	60	32	58	52	26·2
30	SICKLE PITS	18	28	16	56	48	44
31	SMALL CON.FRACS	52	64	50	65·5	56	18·2
32	SMOOTH CAPPING LAYER	36	42	20	26·5	16	29·8
33	IRREG.SOL./PPT. SURFACE	58	70	64	67	58	13·2
34	CHEM.ORIENT.Vs	16	34	20	26·5	18	17·8
35	L.ISOL.CHEM.Vs	28	18	14	29	14	17·6
36	U.PLATES	10	12	12	38·5	16	24·4

FIG 5.1

CHECKLIST

		FLOOD TIDAL DELTA	INLET	OVERWASH	DUNE	BEACH
1	ANGULAR/ ROUNDED (NOT APPLICABLE)					
2	V.HIGH RELIEF	○	○	○	○	○
3	HIGH RELIEF	●	●	●	●	●
4	MEDIUM RELIEF TOP.POS.AREAS	■	●	●	●	●
5	LOW RELIEF	○	○	○	●	○
6	SMOOTH	○	○	○	○	○
7	V.HIGH RELIEF	○	○	○	○	○
8	HIGH RELIEF	○	○	○	○	○
9	MEDIUM RELIEF TOP.NEG.AREAS	●	○	○	○	●
10	LOW RELIEF	●	■	●	■	●
11	SMOOTH	○	●	○	●	○
12	CONCAVE UP	●	●	■	●	●
13	CONVEX UP	●	○	●	○	●
14	DISH SHAPED CONCHOIDAL FRACS.	○	●	○	●	○
15	CON.FRACS.& ARCUATE STEPS	○	○	○	○	○
16	RADIATING STEPS	○	●	○	○	○
17	CRACKS	●	■	●	■	■
18	SEVERE EDGE ABRASION	●	■	●	●	●
19	MODERATE EDGE ABRASION	●	●	●	■	●
20	MILD EDGE ABRASION	○	○	○	○	○
21	L.IRREGULAR BLOCKY DEPRESSION	○	○	○	●	●
22	ISOL.L.V.SHAPED BLOCKS	●	●	●	■	■
23	L.BLOCKS	○	●	○	○	■
24	L.FLAT AREAS	●	■	■	■	●
25	PARALLEL STRAIGHT SCRATCHES	○	○	○	○	○
26	CURVED SCRATCHES	●	●	●	○	○
27	STRAIGHT SCRATCHES	○	○	○	●	●
28	M.V.s	■	■	■	●	■
29	IRREGULAR PITS	●	■	●	■	■
30	SICKLE PITS	○	●	○	■	●
31	SMALL CON.FRACS	■	■	■	■	■
32	SMOOTH CAPPING LAYER	●	●	○	●	○
33	IRREG.SOL./PPT. SURFACE	■	■	■	■	■
34	CHEM.ORIENT.Vs	○	●	○	●	○
35	L.ISOL.CHEM.Vs	●	○	○	●	○
36	U.PLATES	○	○	○	●	○

■ 75–100%

■ 50–75

● 25–50

○ 0–25

The Inlet samples have demonstrated various multicycle surface patterns (see Plate 6). This may be a direct result of reactivation of grain movement during Inlet processes. The samples indicate a glacial - fluvial regime.

(c) Flood Tidal Delta

F.T.D. grains were predominantly angular (78% to 12% round grains), a similar ratio to the Inlet grains, understandably given the generic link between the two geomorphic elements. Topographical relief is generally similar to Inlet results (see Table 5xv).Edge abrasion was also similar but isolated large 'V' shaped blocks and large flat areas were reduced. Irregular solution/precipitation surfaces diminished (58% to 70% for Inlet), possibly as a result of reactivation in delta formation. Chemical 'V'S were noticably reduced possibly due to the same reactivation processes, disturbing quiessence periods.

The F.T.D. grains displayed morphology ranging from angular, moderate sphericity grains, to elongate low sphericity grains. As found in other samples large flat areas were the dominant large scale feature. Edge abrasion ranged from severe to moderate M.V's were common but blocky topography was reduced, as compared to all the other samples. Generally the grains displayed multicyclicity, with an old mechanical surface covered by a chemical solution/precipitation then affected by a secondary mechanical phase. The old surface appears to be derived from an earlier sedimentary transportation/deposition cycle, and is superimposed during residence time in the nearshore sinks.

(d) Overwash

The overwash sample contained a higher proportion of rounded grains (62%/34%) than the other sampled environments, possibly an indication of the presence of dune sample grains, incorporated when washover breaks through the dune crest.

Dominant overwash textures included large flat areas, leading edge abrasion and multicycle surface features/isolated large 'V' shaped blocks were common. Few aeolian features were visible, but several of the grains have spent periods of quiessence possibly in the dune sink before reactivation.

(e) Dune

The dune sample contained a high percentage of rounded grains (29%) similar to results for the overwash sample. This is to be expected, with washover breaking through the dune line incorporating large amounts of dune sediments, an assumption indicated by the statistical results (Chapter 5 (i) a), where 42% of the dune sample was misclassified.

Large scale C.F's were reduced in the due sample compared to overwash (54% - 29%). Cracks were abundant with generally moderate edge abrasion. Large flat areas were again prominant. M.V's were present but in reduced number, attesting to the fluvial dominance in the nearshore zone. Small C.F's and sickle pits were generally abundant.

Few classic dune sediment textures were seen, and this is due to interchange between other nearshore sinks, with the dune acting as a ubiquitous sink. As with other samples an original mechanical surface was evident.

Beach

Plate 1

Subangular grain with large flat areas. Edge abrasion is moderate to severe V-shaped notches and M.V's are prevalent.

Plate 2

Angular grain with cracks and moderate to severe edge abrasion. Large flat areas are prevalent.

Plate 3

Subangular grain, moderate edge abrasion, and widespread large-scale conchoidal fractures.

Plate 4

M.V's are widespread, associated with V-shaped notches.

Plate 5

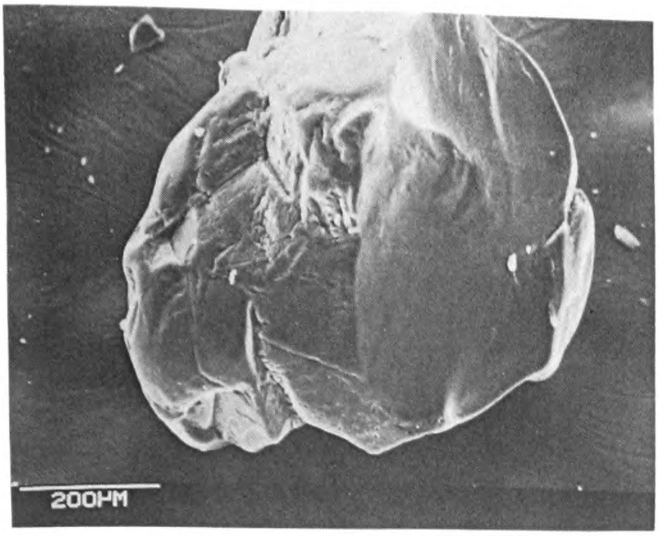
A close-up of Plate 1. A large V-shaped notch.

Plate 6

Edge abrasion with small V-shaped notches.

BEACH PLATES

1



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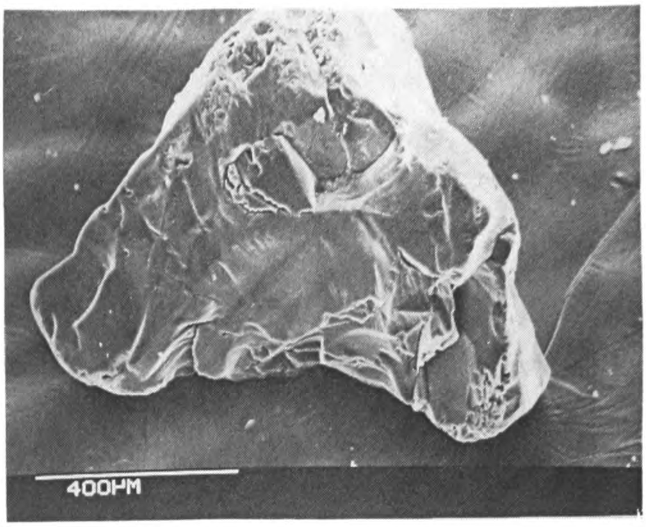

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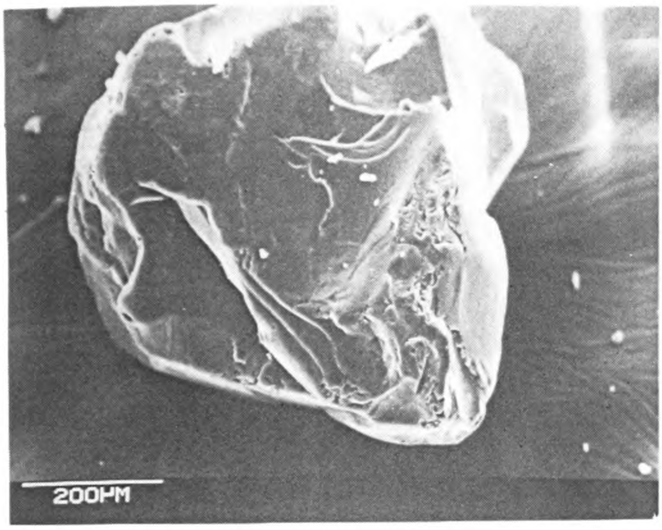

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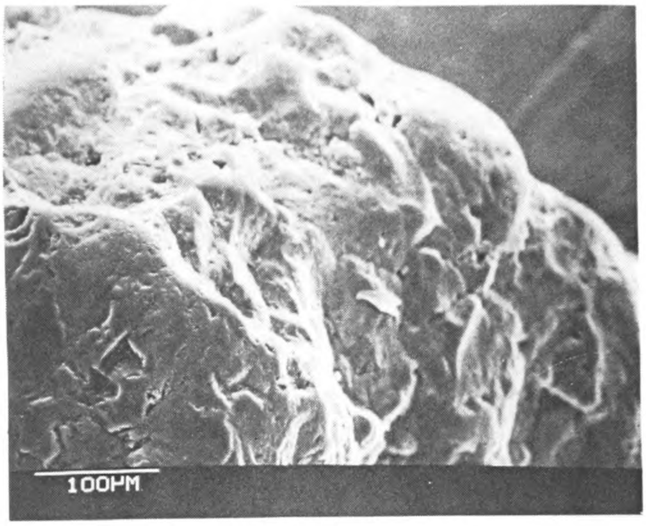

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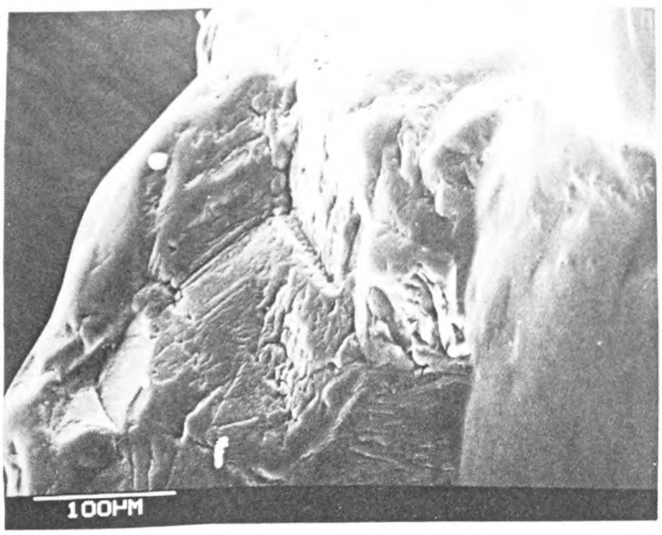

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Plate 7

Angular grain with large flat areas. V-shaped notches and M.V's again common.

Plate 8

Large subangular grain with small V-shaped notches, M.V's and surface breakage.

Plate 9

Large scale conchoidal fracture with mild edge abrasion.

Plate 10

Angular grain with large flat areas and small pits.

Plate 11

Angular grain, large flat areas.

Plate 12

Large scale conchoidal fracture and little evidence of fluvial action.

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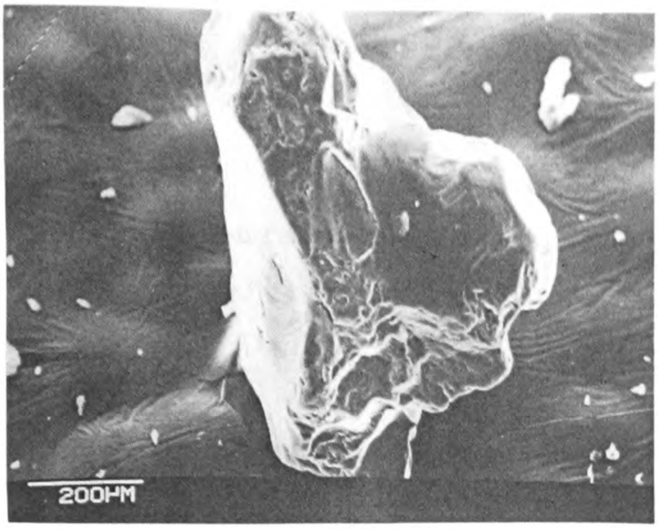

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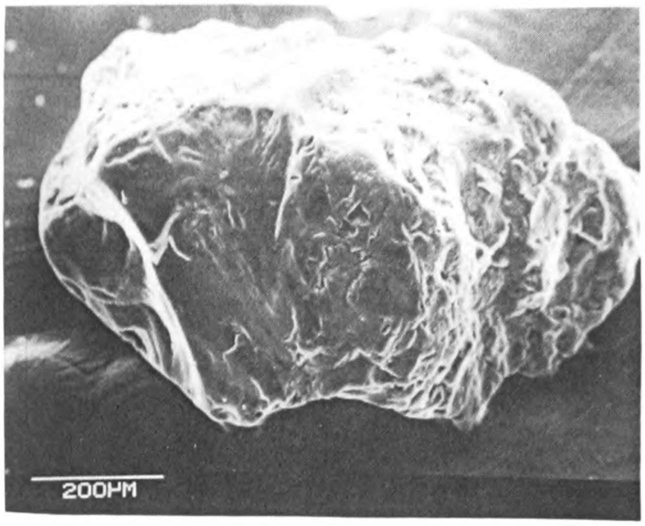

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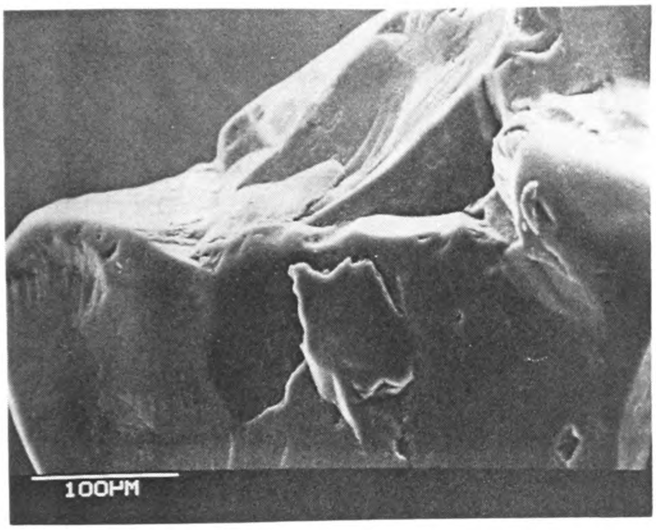

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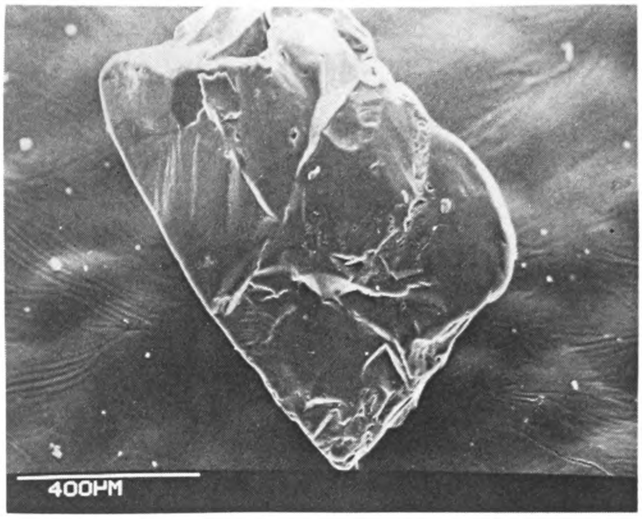

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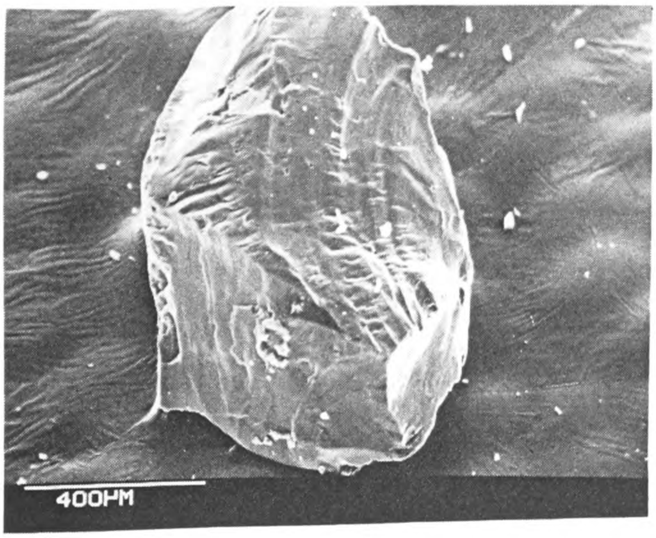

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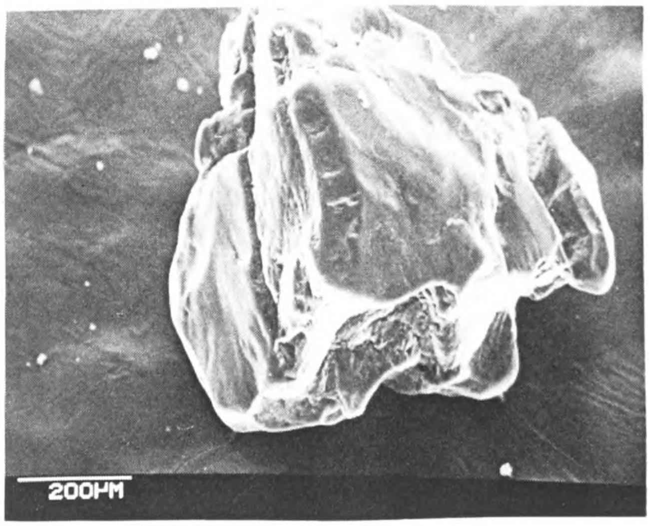


Plate 13

Surface abrasion coupled with chemical action is seen. M.V's are found.

Plate 14

V-shaped notches are found. An original mechanical surface is seen to the right.

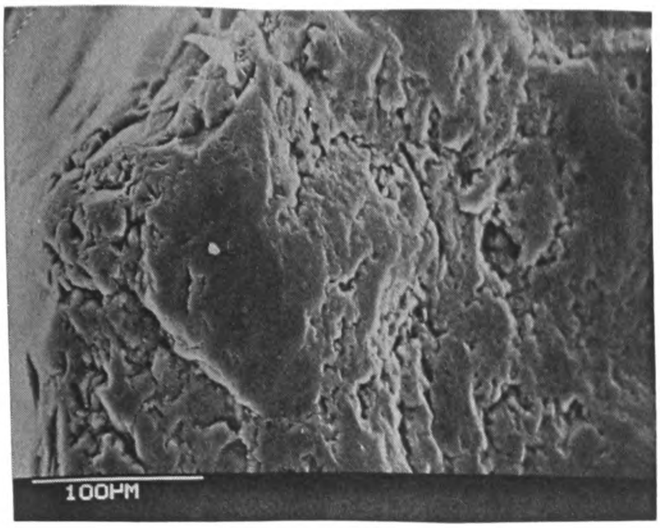
Plate 15

Subangular grain (see Plate 13) indicating surface abrasion with possible chemical alteration.

Plate 16

Angular grain (see Plate 14) displaying an original mechanical surface superimposed by a second mechanical breakage episode including V-shaped notches and M.V's.

13



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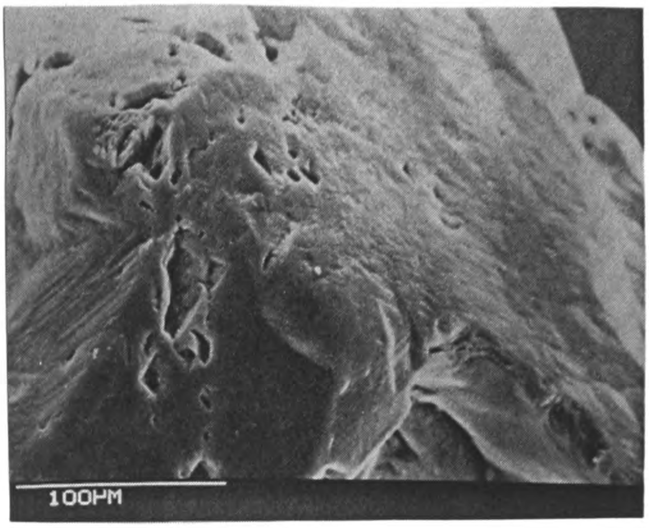

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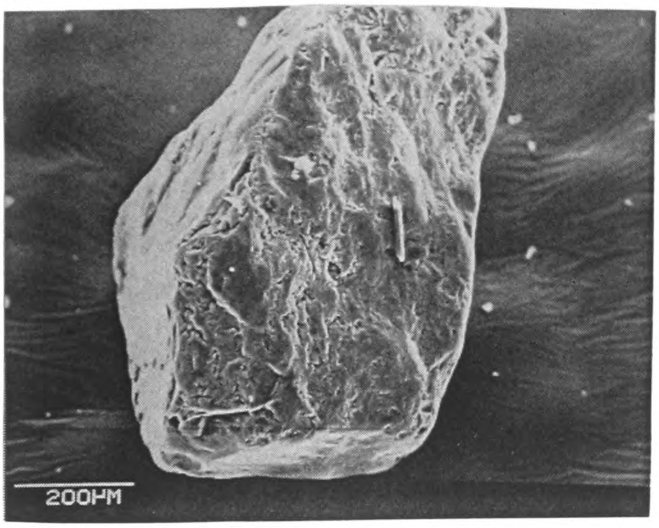

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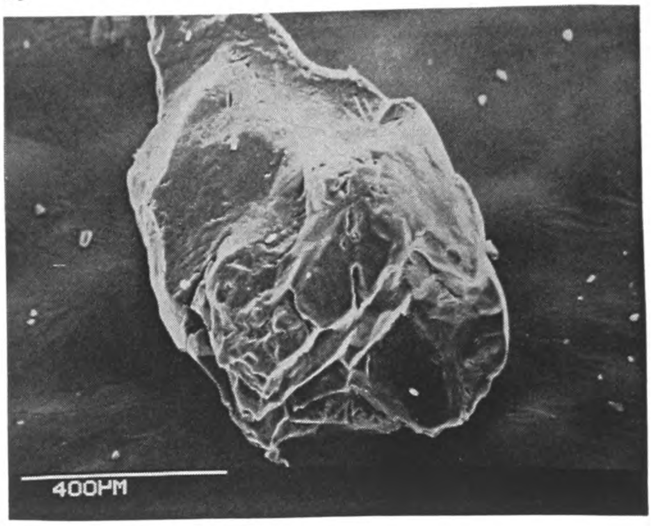


Inlet Plates

Plate 1 and 2

These elongate angular grains were found also in the Flood Tidal Delta and overwash samples. 'V' shaped notches, arette type edge configuration and mechanical 'V's (M.V.'s) are seen coupled with small type conchoidal fractures.

Plate 3

In contrast to Plates 1 and 2, a subrounded grain displaying M.V's, small V-shaped notches, conchoidal fractures and cracks, in conjunction with some chemical solution/ precipitation.

Plate 4

An angular grain with predominant leading edge abrasion. Large flat areas and conchoidal fractures are present, found with silica precipitation/solution.

Plate 5

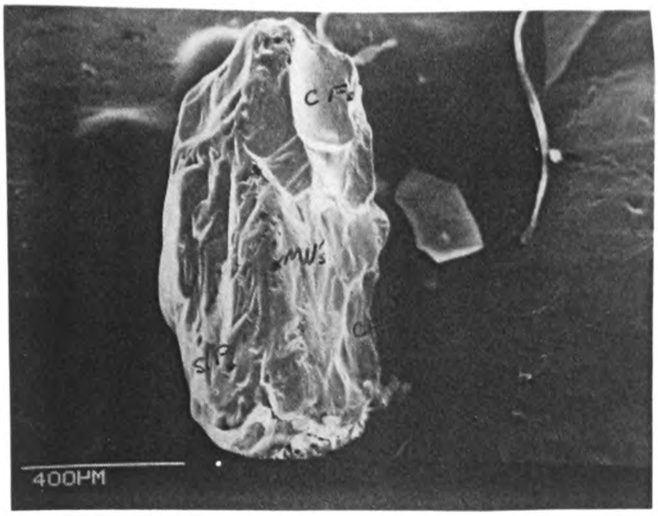
A subangular grain with large flat areas. Similar to some overwash grains. There is little leading edge abrasion.

Plate 6

A conchoidal breakage area with varying size of breakage pattern. Two stages of development interspersed with a chemical episode are recognised.

INLET

1



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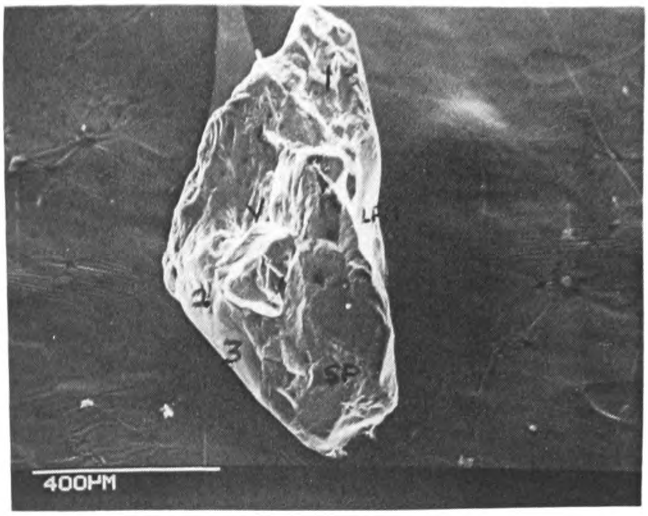

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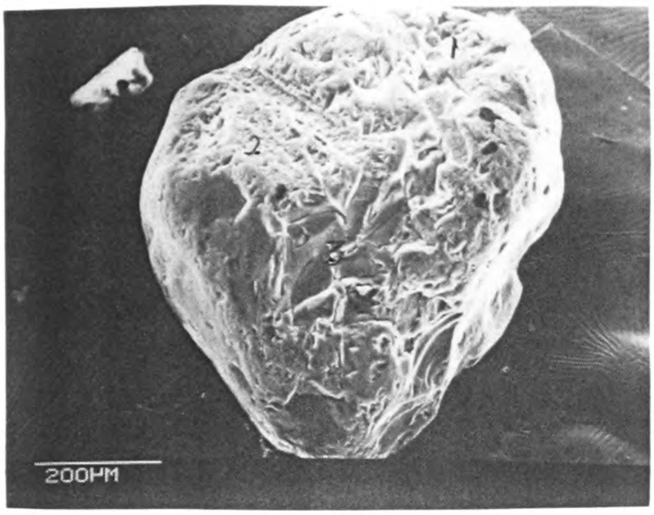

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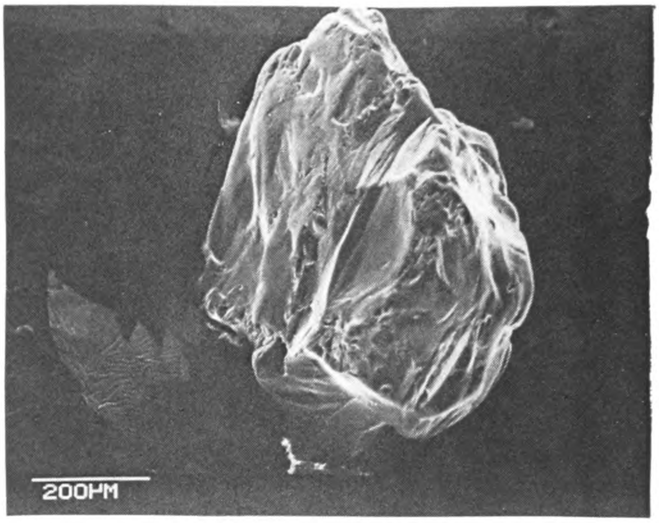

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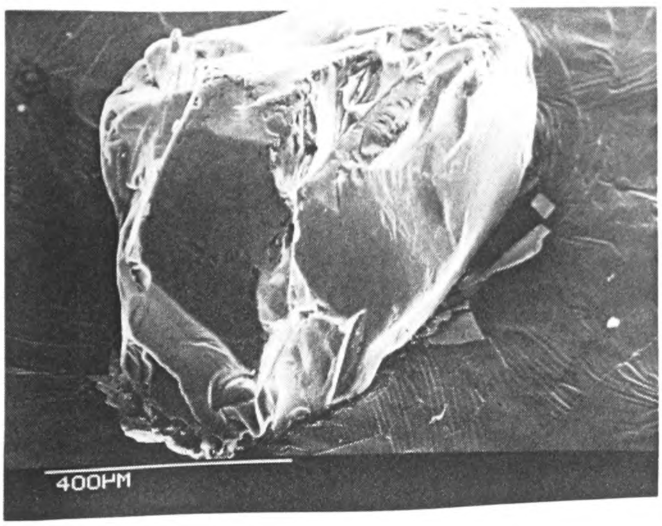

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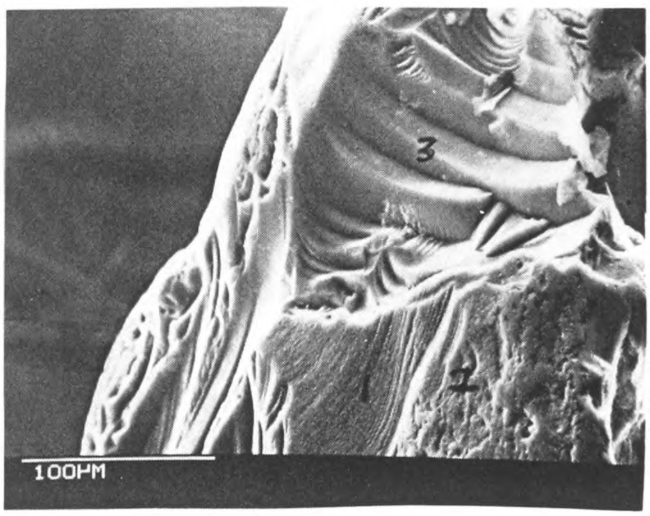


Plate 7

An old conchoidal fracture breakage area coupled with a solution/precipitation phase.

Plate 8

A leading edge breakage zone, with small C.F's, V-shaped notches and M.V's. There is the possibility of 2 stage mechanical abrasion.

Plate 9

Large V-shaped depression, with M.V's and notches, Silica precipitation is prevalent.

Plate 10

Subangular grain displaying large flat areas disrupted by severe edge abrasion/grain breakage.

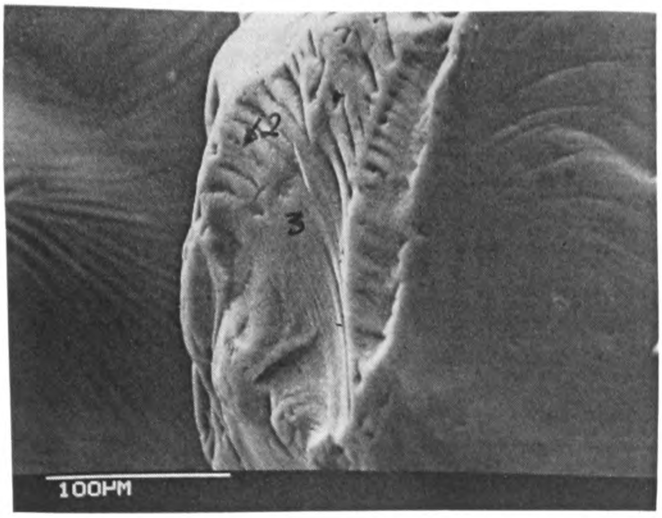
Plate 11

Mechanical and chemical 'V' pits.

Plate 12

Chemical/mechanical 'V' pits.

7



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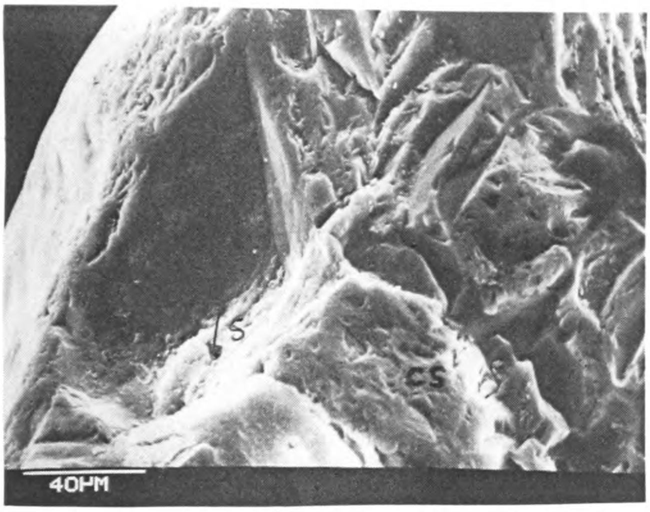

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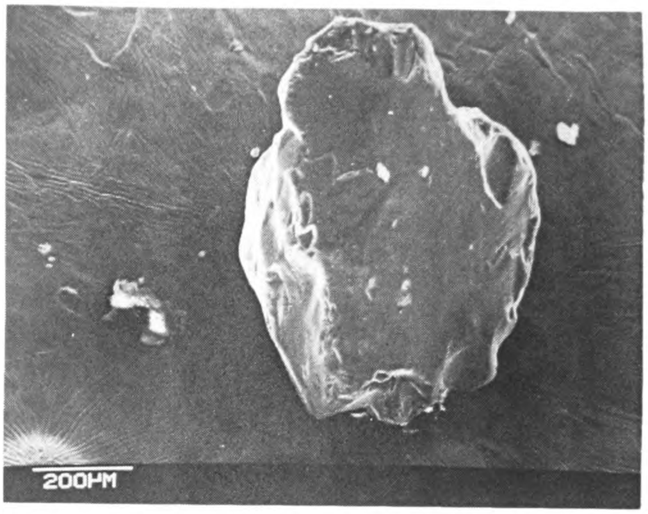

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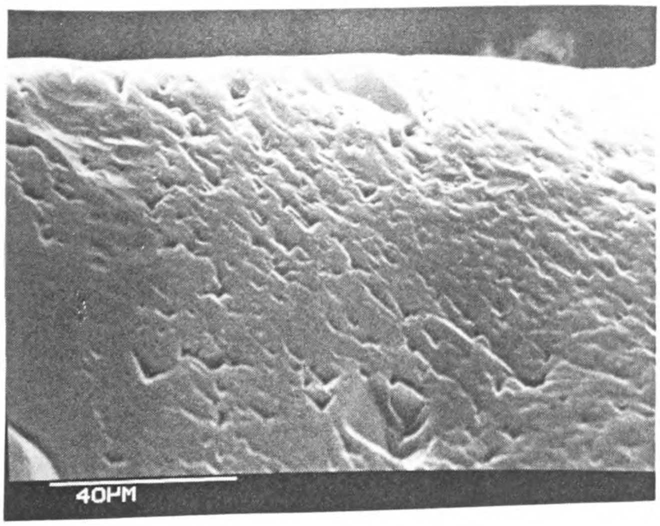

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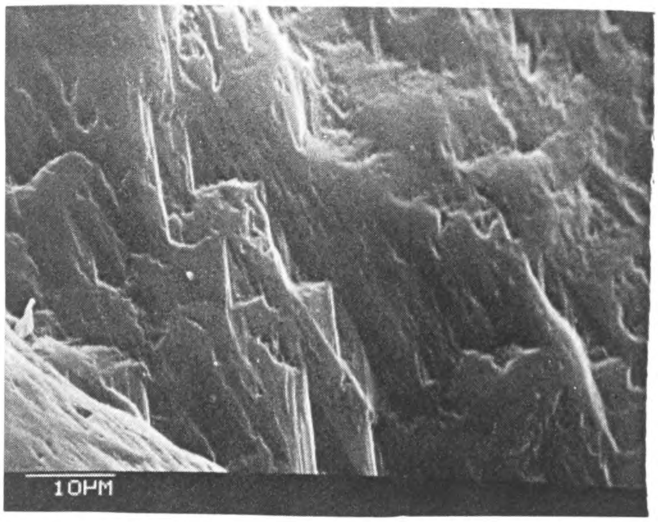


Plate 13

Subrounded grain with silica precipitation surface covering an old C.F. breakage surface.

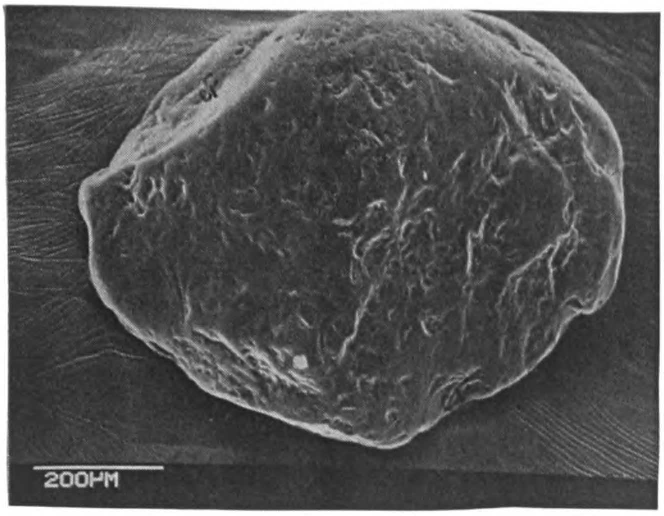
Plate 14

Small C.F's and severe leading edge abrasion. M.V's and chemical V's are seen.

Plate 15

Multicycle mechanical/chemical surface. Renewed mechanical action cuts across old chemical surface.

13



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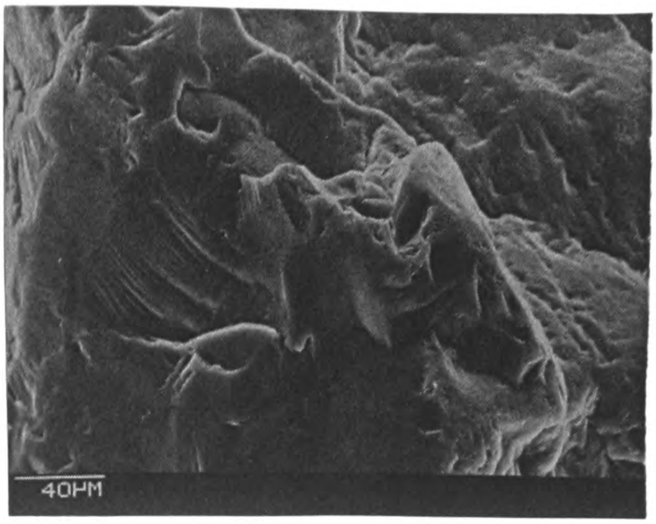

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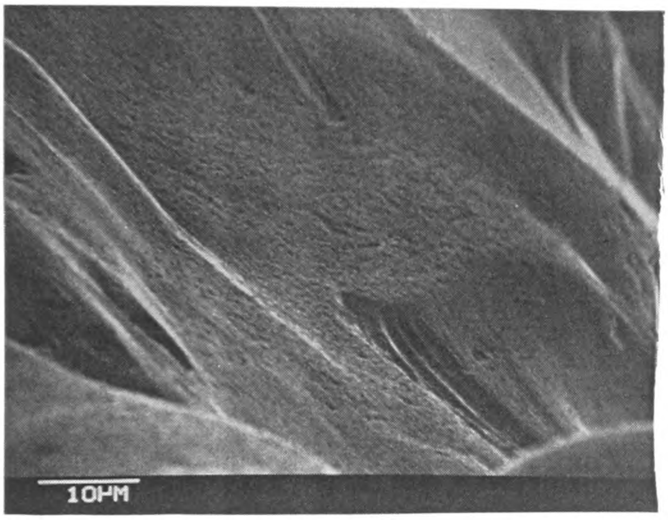


Flood Tidal Delta

Plates 1 and 2

Both are elongated grains with high topographically positive relief. Leading edges are formed by conchoidal fracture combination creating arrete like features (see Plate). Edge abrasion is severe but there is little chemical activity.

Plate 3

A subangular grain displaying blocky topography, with large flat areas. Grain breakage is apparent.

Plate 4

A subrounded grain with medium sphericity. Old C.F's are present, coupled with large scale surface breakage, possibly from surf action.

Plate 5

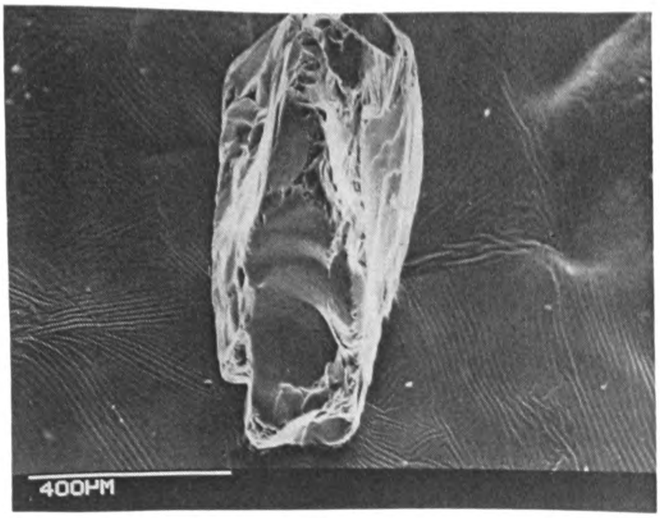
A close-up of grain 4 (top left corner) highlighting surface abrasion in the form of M.V's, grading into microblocks. Some chemical activity is present, with renewed mechanical abrasion, removing much of this. As in other grains, a multicycle abrasion/chemical solution/precipitation sequence is indicated.

Plate 6

Leading edge abrasion is shown. 'V'-shaped notches developing from M.V's, C.F's, grading into large flat areas are prevalent. Little chemical activity is indicated.

FLOOD TIDAL DELTA

1



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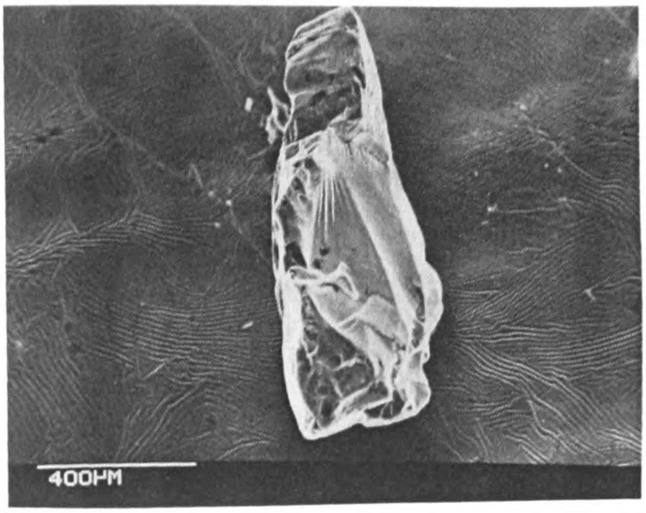

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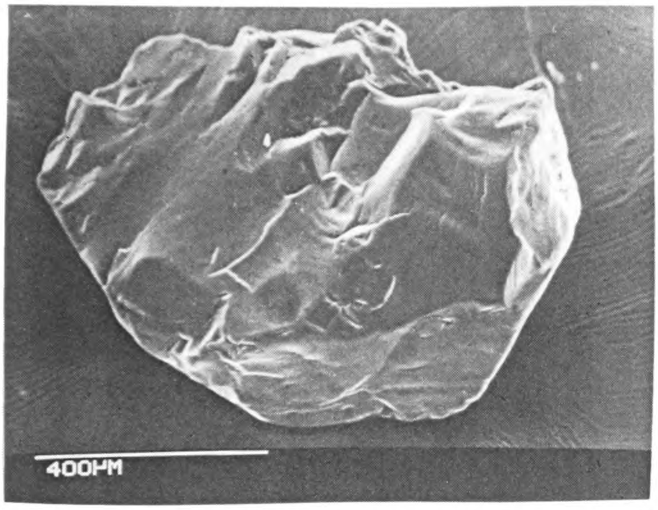

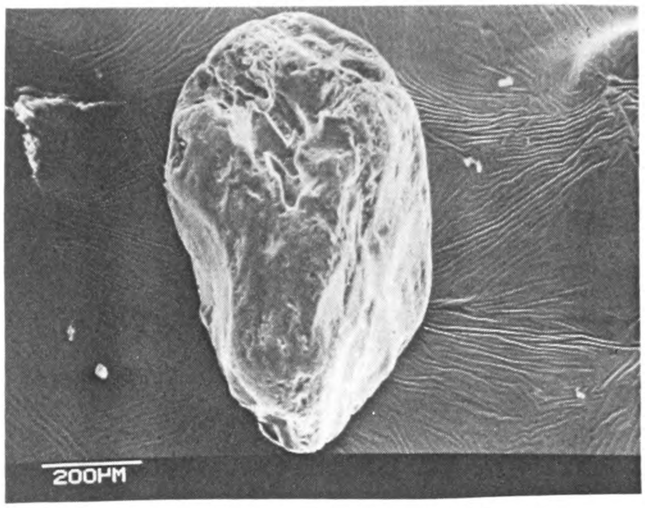

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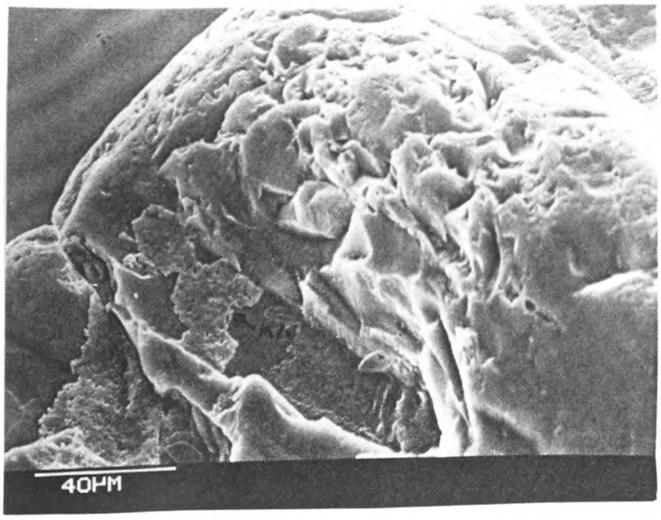

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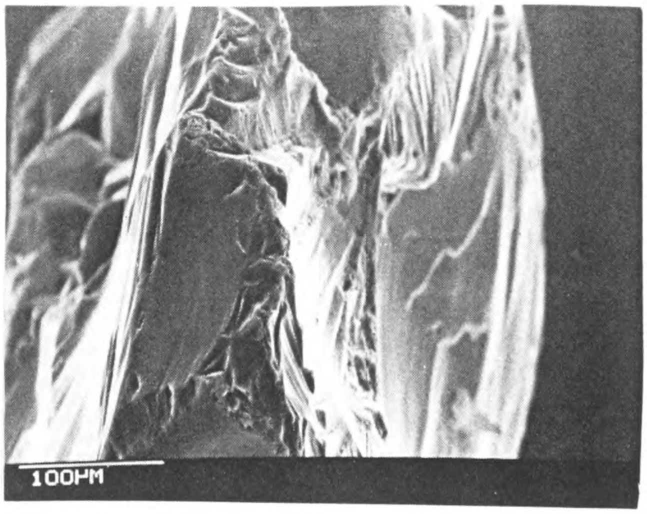


Plate 7

Close-up of Plate 1 indicates C.F. development coupled with grain breakage. Silica solution/precipitation is shown.

Plate 8

A close-up of grain 3 showing blocky topography with little mechanical or chemical rounding.

Plate 9

An angular grain with large scale C.F. development producing large flat areas. Few M.V's are present and there is little indication of chemical action.

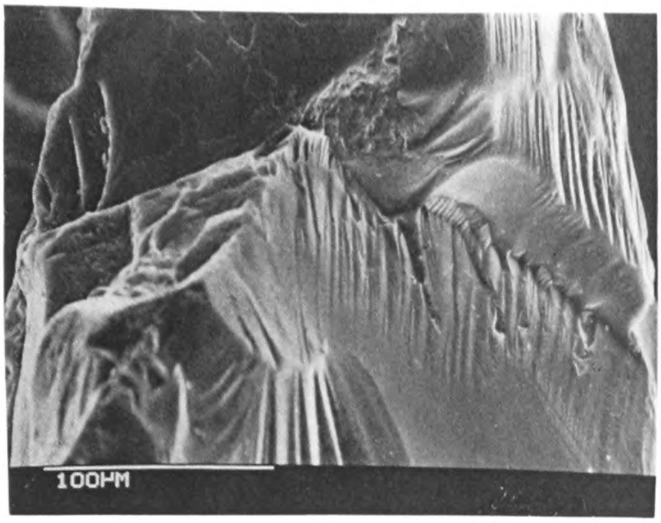
Plate 10

Large scale 'M.V' development emphasing fluvial processes, superimposed on an old mechanical surface.

Plate 11 and 12

An irregular grain (see Plate 1 and 2) with large flat areas coupled with leading edge abrasion and grain breakage. Chemical activity is indicated (Plate 12) with an old mechanical surface covered by irregular solution surface. This grain is similar to offshore source grains (see appendix a).

7



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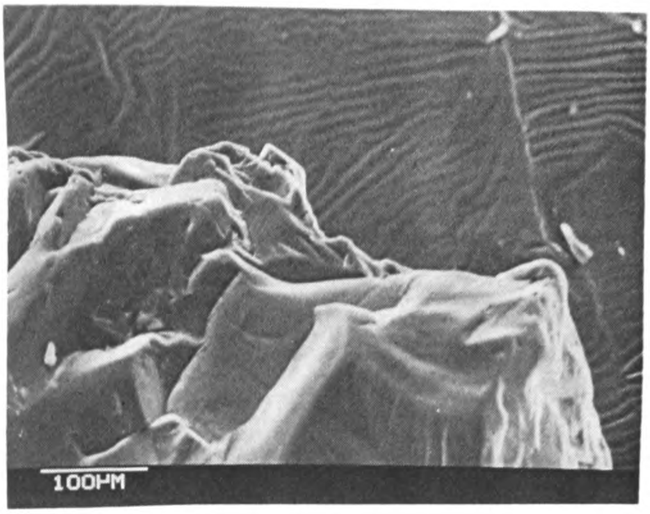

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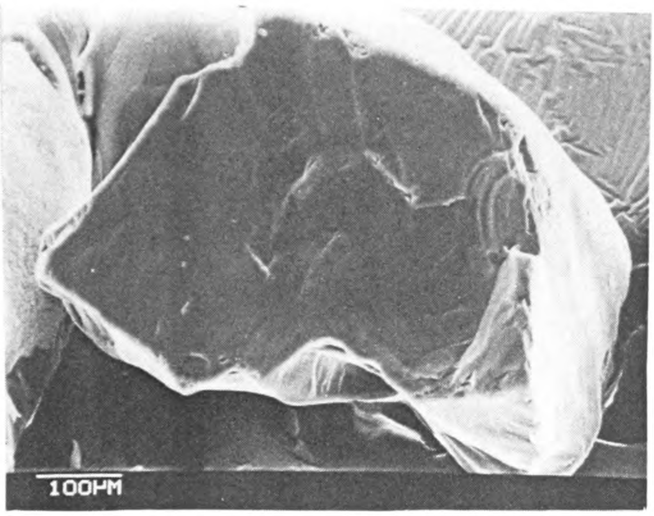

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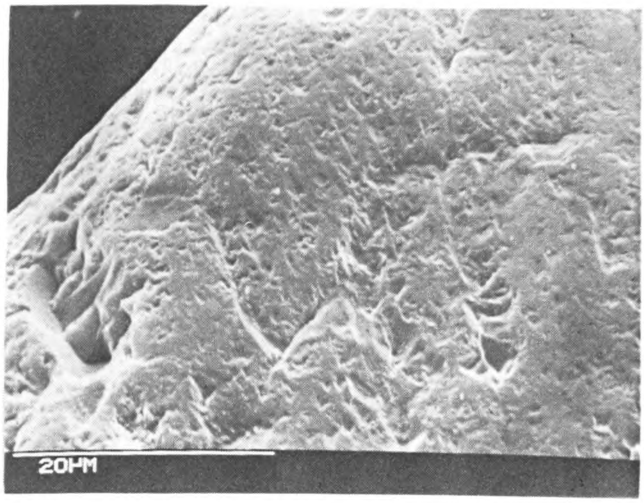

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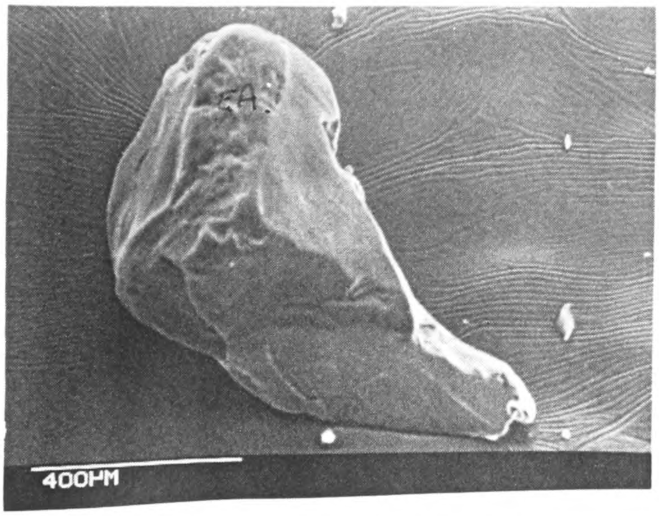

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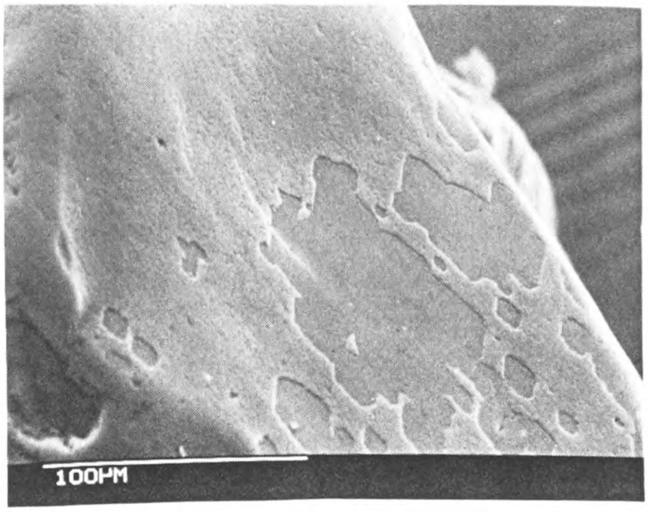


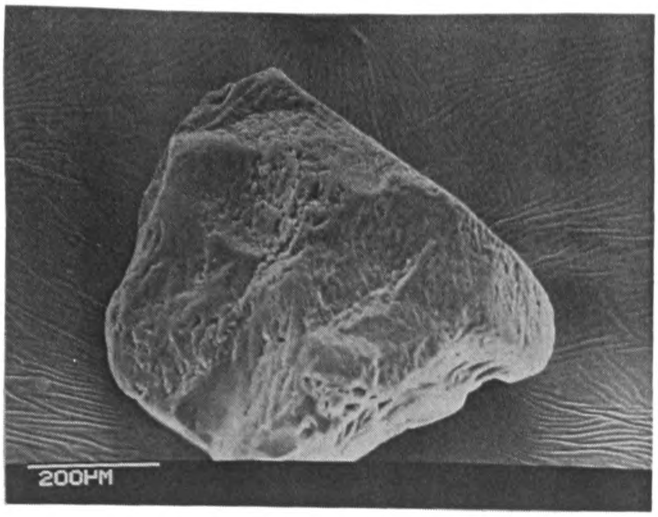
Plate 13

Angular grain with old mechanical surface superimposed by chemical activity.

Plate 14

Angular grain with severe leading edge abrasion, grain breakage with some chemical activity. Large flat areas are visible.

13



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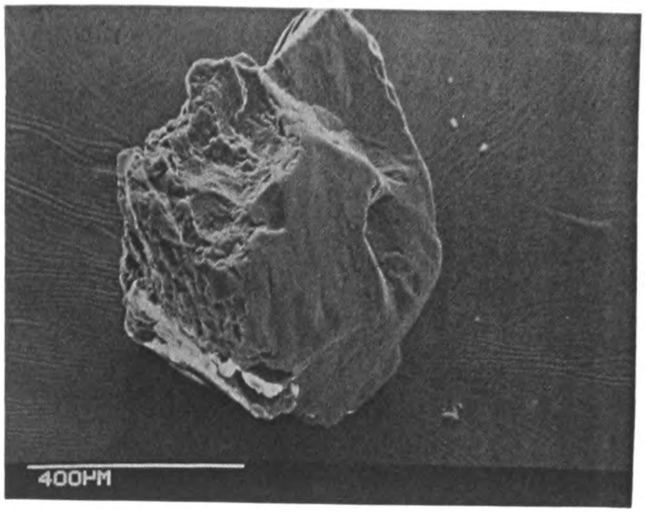


Dune Plate

Plate 1

A subrounded grain with a dulled chemical surface. There is evidence of an original grain breakage area. This grain may be compared to Plate 13 Inlet. Old C.F's, V-shaped notches are present.

Plate 2

A subangular grain with ubiquitous large flat areas and moderate edge abrasion. Small C.F's are common.

Plate 3

Large flat areas displayed with extensive grain breakage areas.

Plate 4

Rounded grain with mechanical V's, covered by silica precipitation.

Plate 5

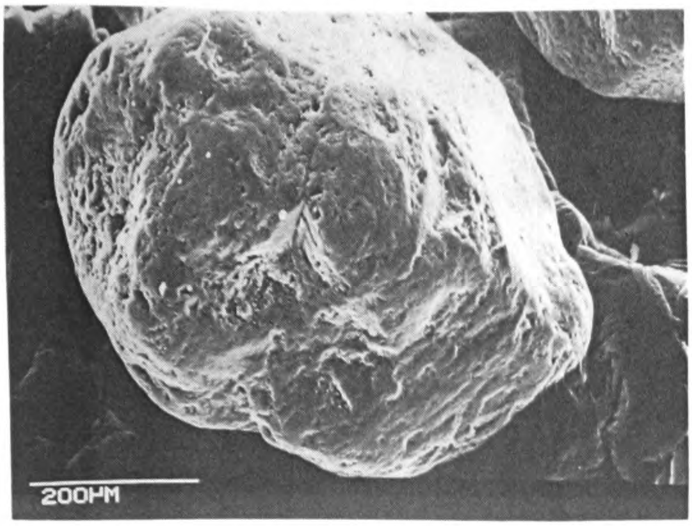
An angular grain with large flat areas and severe leading edge abrasion and M.'V's. Possibly can be equated to several overwash grains.

Plate 6

Severe grain breakage area with cracks and M.V's are present.

DUNE

1



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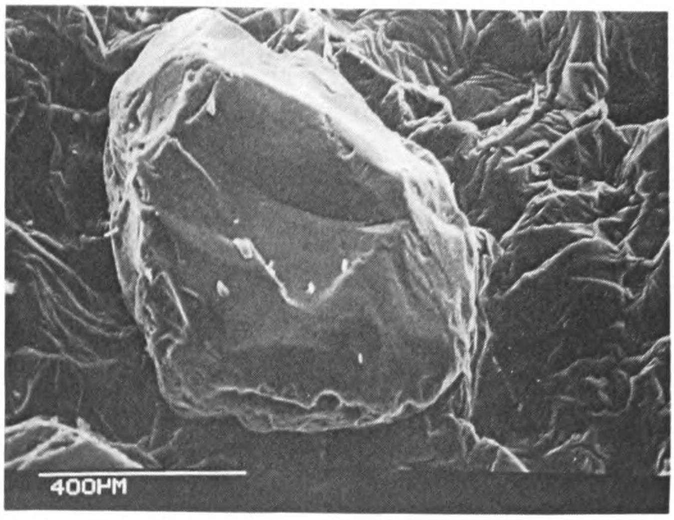

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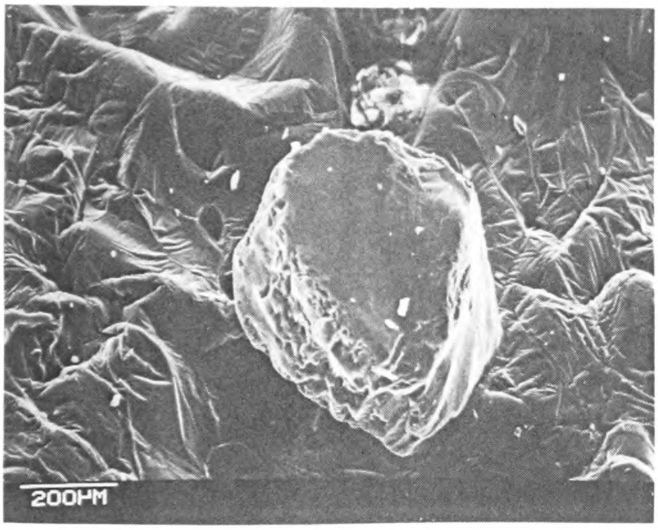

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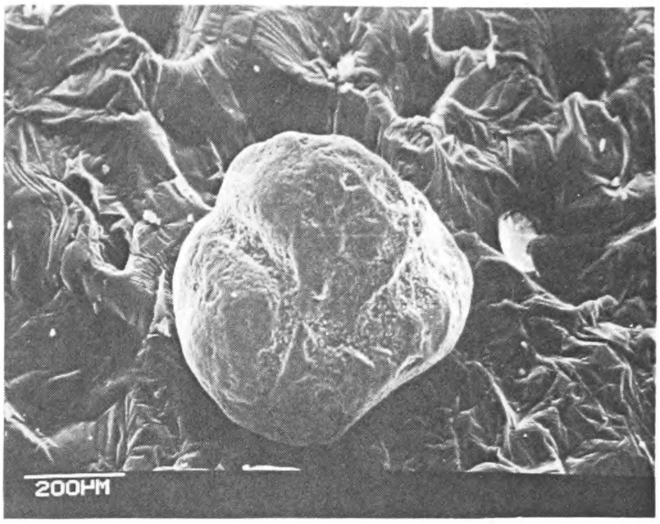

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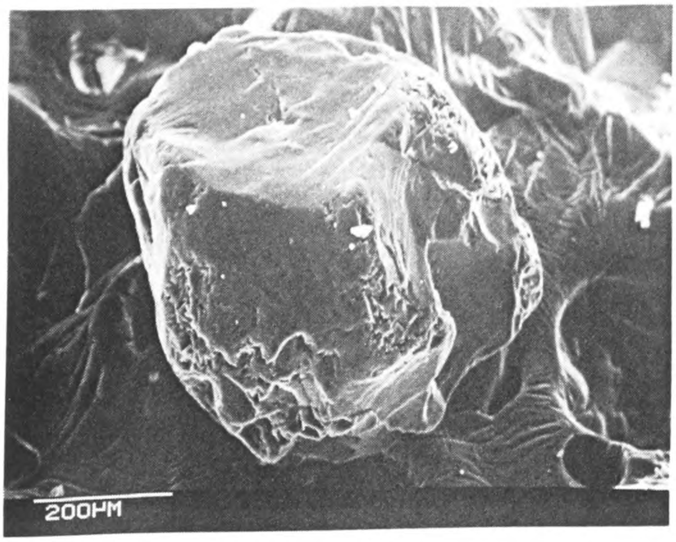

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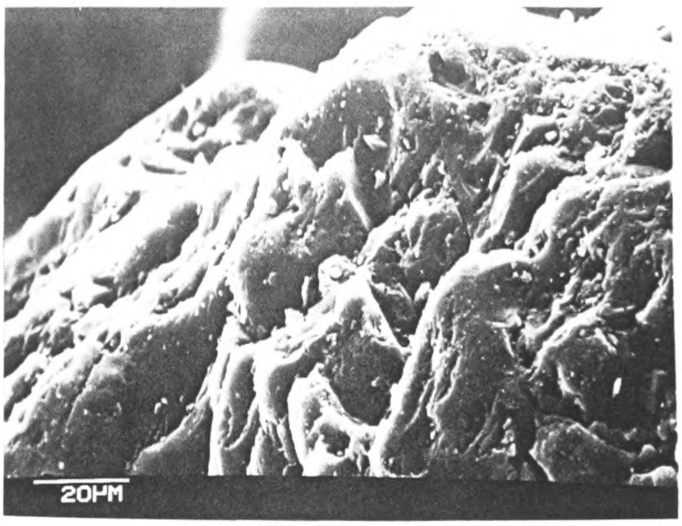


Plate 7

'Fresh' grain breakage with cracks.

Plate 8

An angular grain with ubiquitous large flat areas and little edge abrasion. A similar grain to Plate 3 F.T.D.

Plate 9

C.F. breakage area, similar to Plate 5 Overwash.

Plate 10

Old breakage area with extensive silica precipitation/ solution.

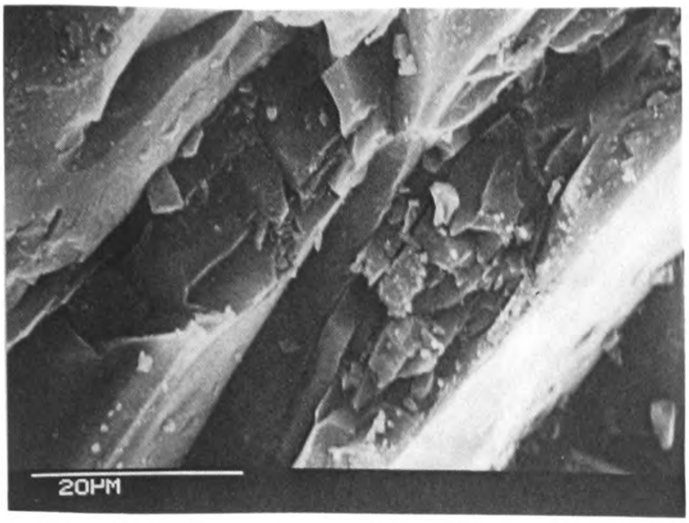
Plate 11

An elongate, angular grain with large flat areas.

Plate 12

Precipitation surface with numerous M.V's covering old mechanical surface.

7



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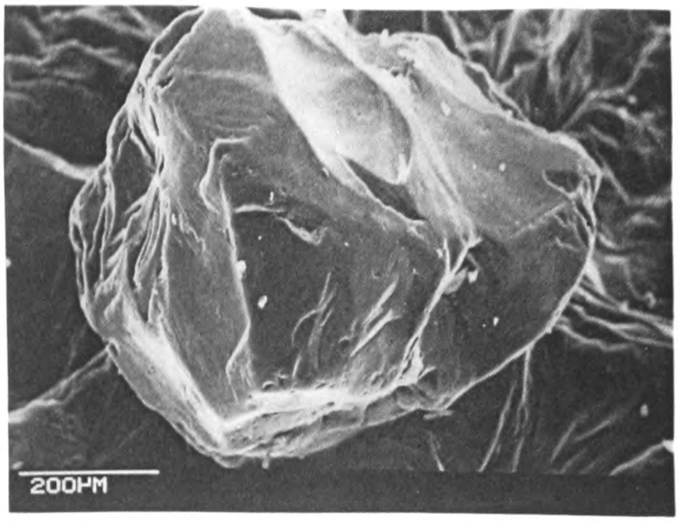

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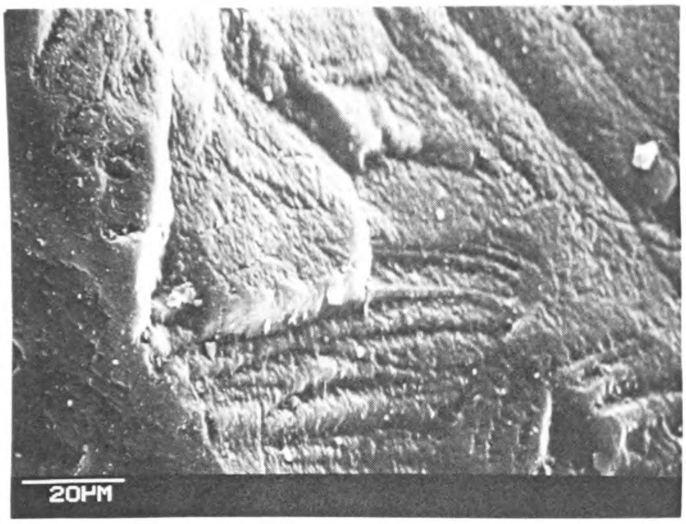

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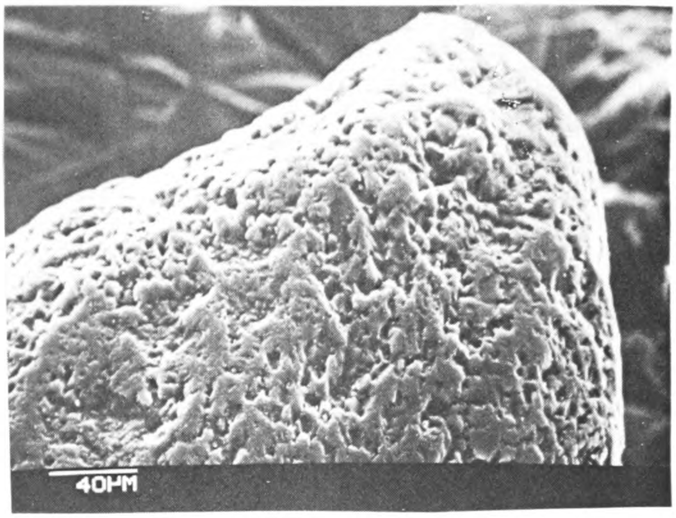

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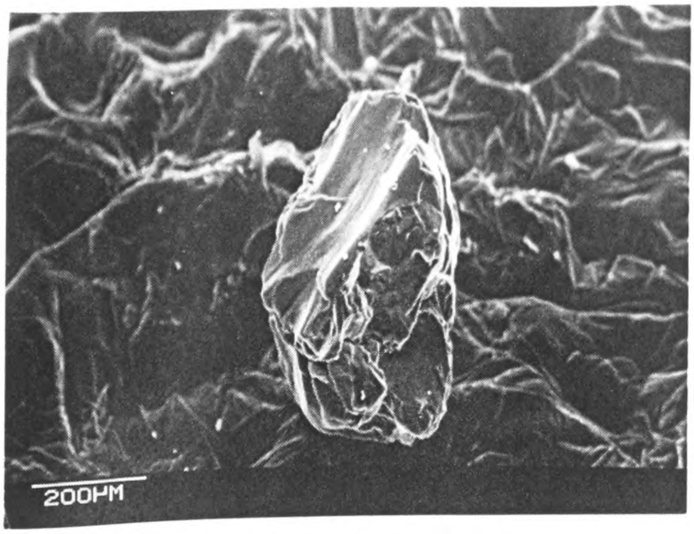

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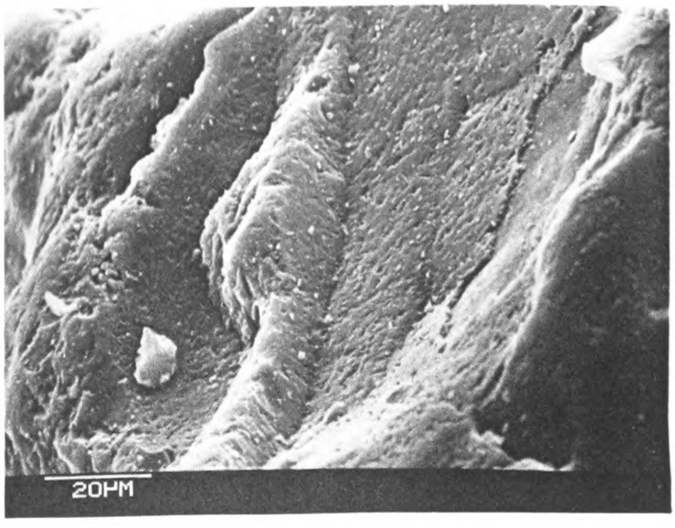


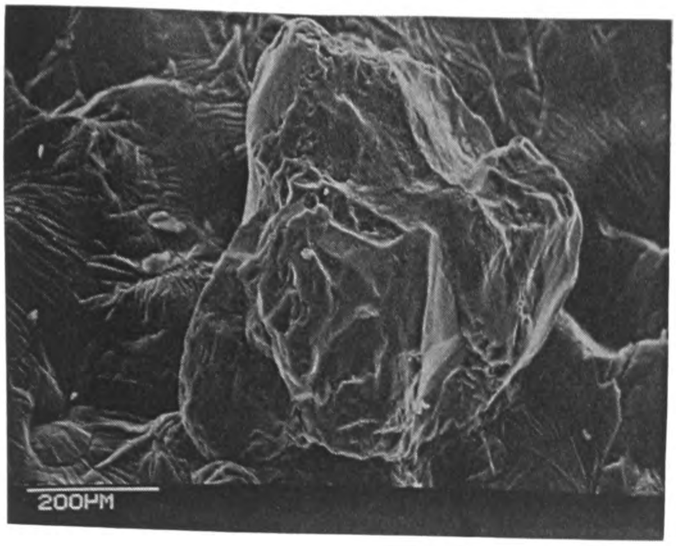
Plate 13

Angular grain, with blocky topography and small C.F's.

Plate 14

C.F. breakage area, with silica precipitation.

13



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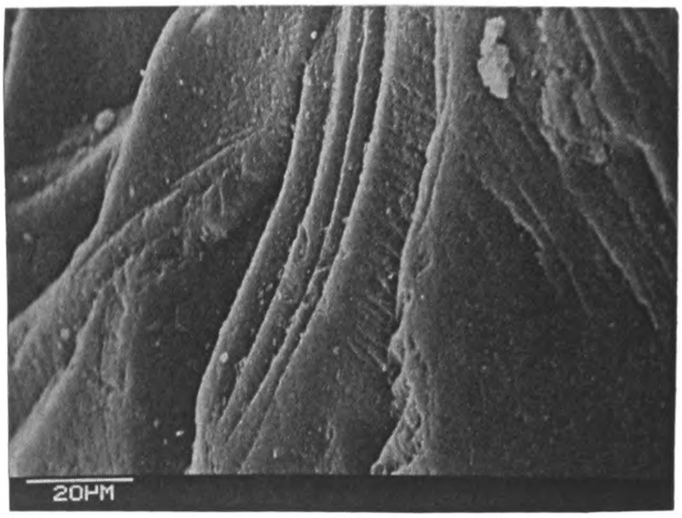

Overwash Plates

Plates 1 and 2

Similar grains to F.T.D. 1 and 2. Elongate with arrete type features. Old C.F.'s and V-shaped notches are common.

Plate 3

Angular grain displaying old C.F's, moderate grain breakage coupled with an original mechanical surface.

Plate 4

Subangular grain with blocky topography, V-shaped notches, M.V.'s and grain breakage.

Plate 5

Old C.F's are shown, superimposed by a solution surface and M.V's.

Plate 6

Large flat areas, edge abrasion, grain breakage, V-shaped notches are displayed on this grain. An old mechanical surface has been reactivated by renewal mechanical abrasion.

OVERWASH

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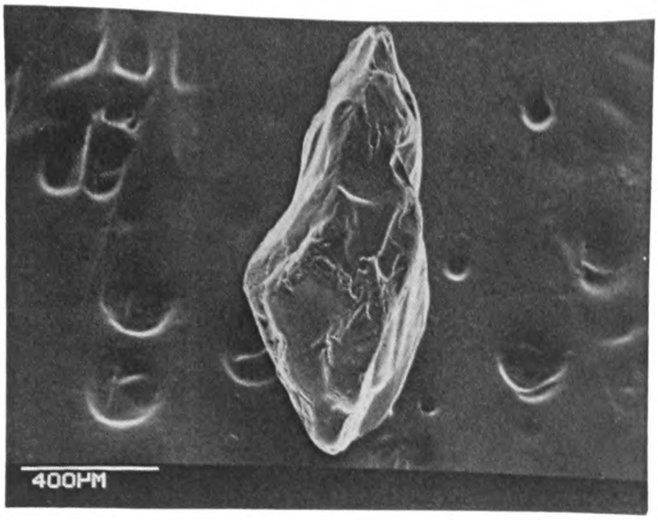

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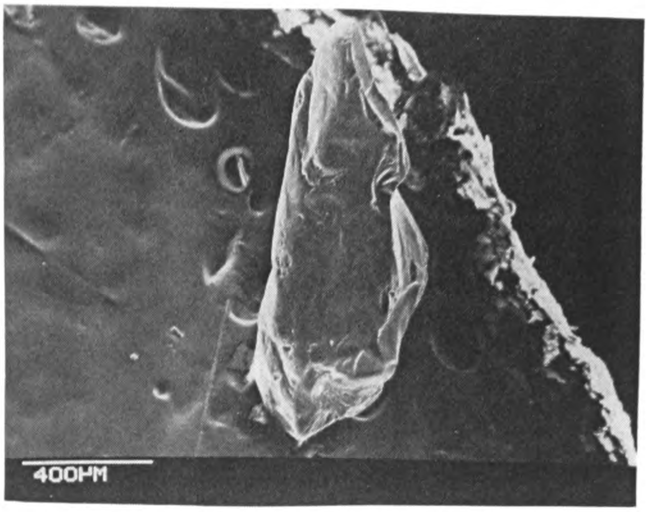

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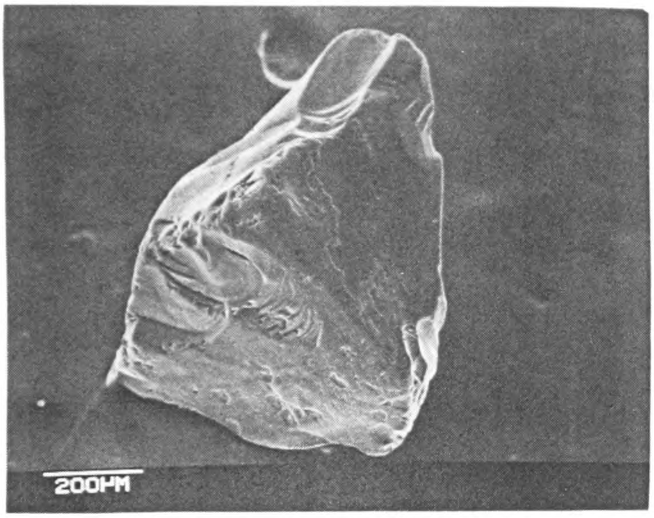

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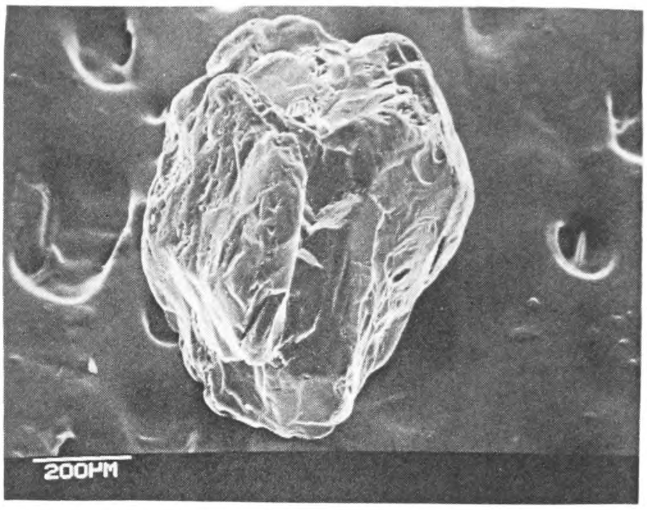

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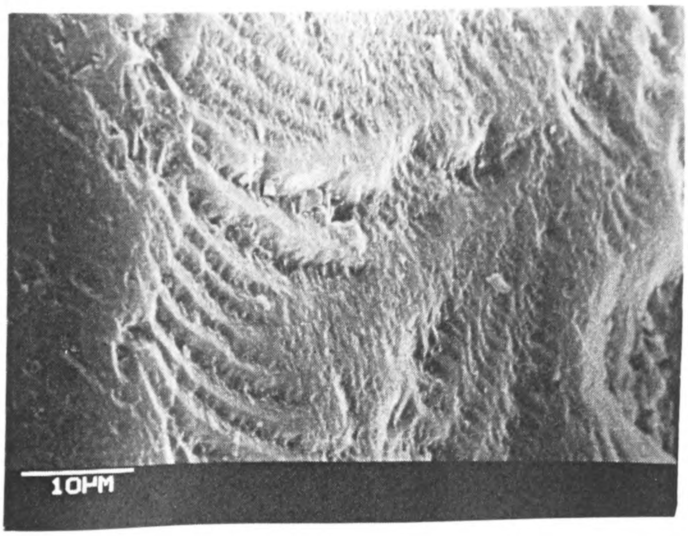

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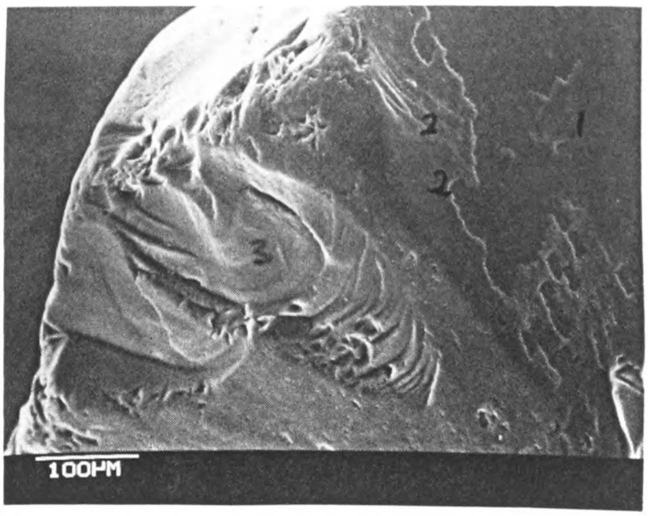


Plate 7

Displayed is blocky topography, with conchoidal fracture 'steps'. There is little leading edge abrasion.

Plate 8

Two contrasting faces (1) old mechanical surface with subdued relief including M.V's, V-shaped notches. This is truncated by (2) renewed mechanical surface, in the form of C.F's.

Plate 9

Old mechanical surface covered by silica precipitation/ solution surface. There is little edge abrasion or M.V's.

Plate 10

Severe edge abrasion with V-shaped notches. Large flat areas are again evident.

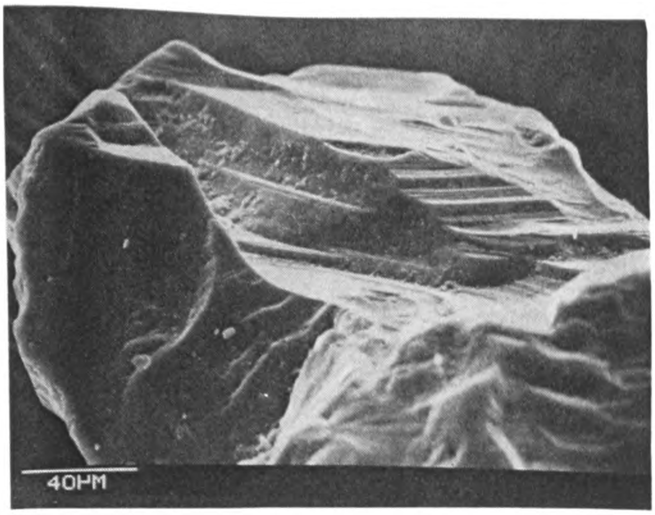
Plate 11

A chemical solution/precipitation surface covering an old mechanical surface.

Plate 12

Close-up of grain 3 with leading edge abrasion. New mechanical features especially C.F's cut across existing flat areas.

7



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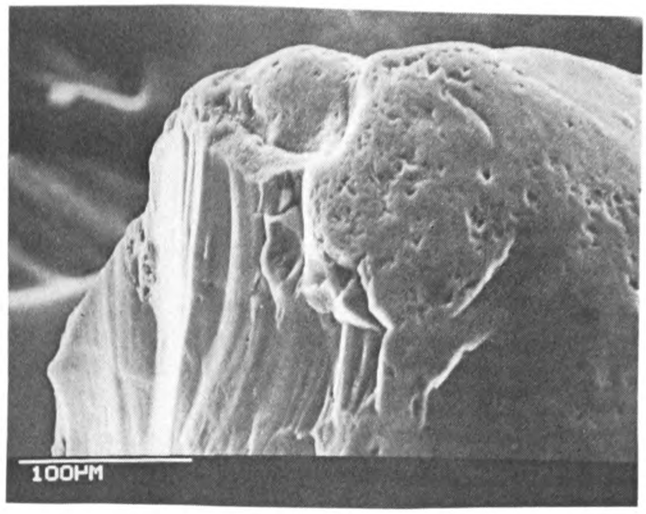

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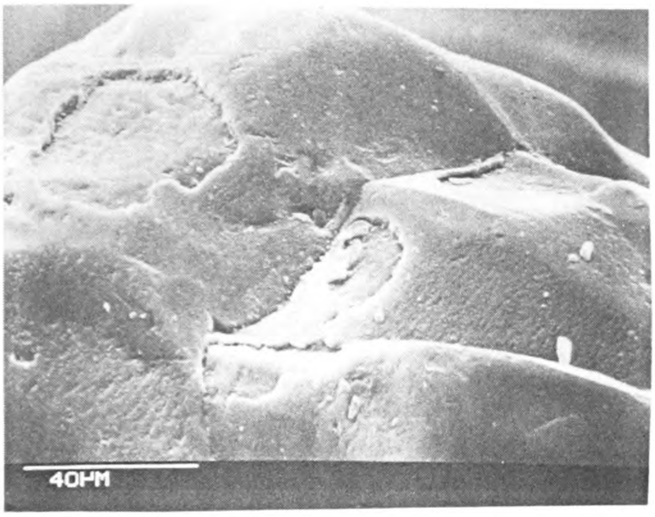

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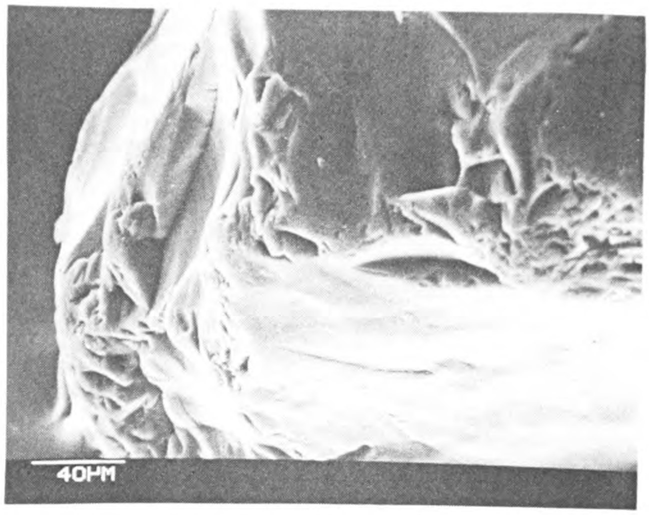

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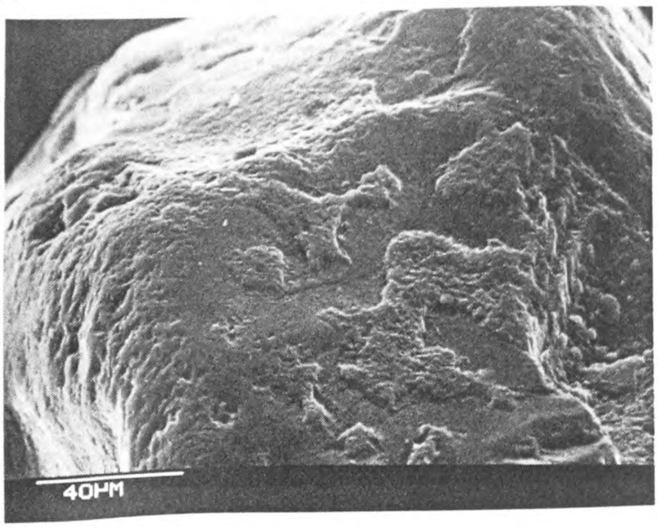

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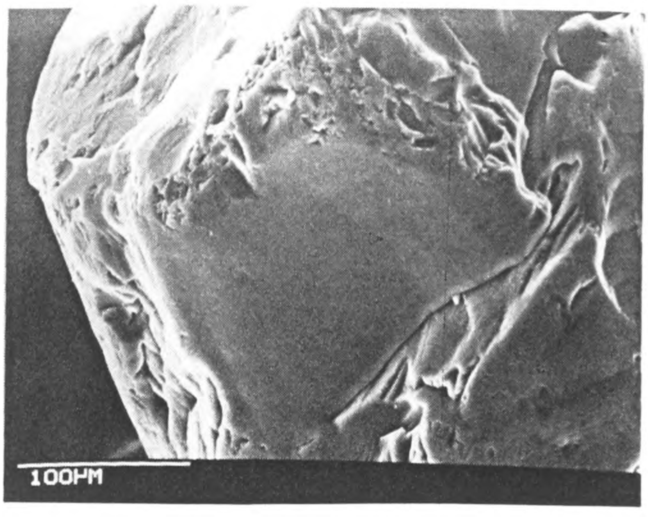

Plate 13

Leading edge abrasion cutting across large flat areas.

Plate 14

Severe edge abrasion, with C,F's and a chemical precipitation/solution surface.

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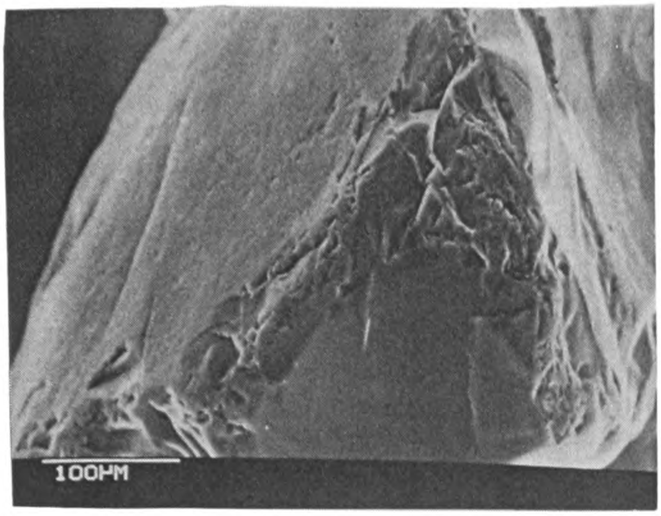

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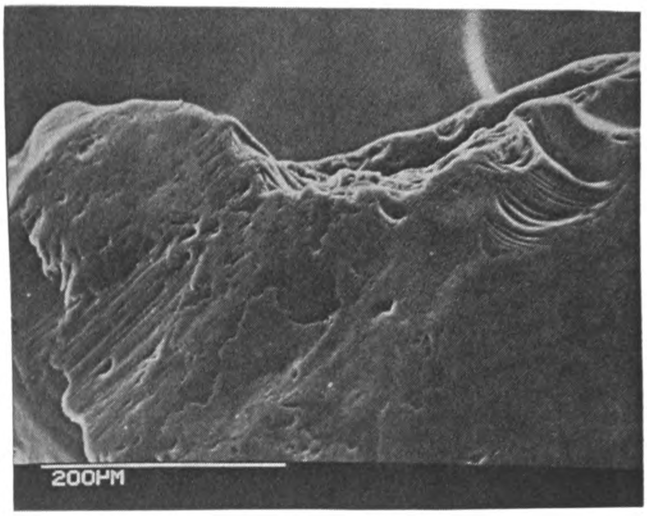

5 (iii) Discussion

Attempted discrimination between nearshore Barrier Island sediments was made on three fronts:-

(1) Visual evidence

(2) Checklist data

(3) Statistical analysis

The approach fulfilled earlier calls for a combination of qualitative and quantitative analysis (Krinsley and Marshall, 1983). The present work must not be viewed in isolation but as part of an ongoing pattern of research, utilizing many different sedimentological techniques, S.E.M. analysis providing but one new piece of information. Grain surface textures, from the five nearshore environments, analysed using photographic and checklist data, revealed sediment depositional history, and interconnectedness between onshore and offshore sediment sources and the nearshore sinks. This analysis allowed tentative ideas to be forwarded, to better understand Barrier Island dynamics and sediment transport/deposition.

The two major factors responsible in surface texture development, of the nearshore grains were:-

(a) Provenance

(b) Homogenization.

The glacial input into the littoral system, whether from Montauk Point or the offshore lobes, provided the basic textures, upon which the nearshore processes of longshore drift and onshore 'sink' transport and deposition have superimposed new textural suites. In almost all samples an early stage mechanical surface was evident (see Chapter 5, Inlet plate 6, Overwash plates 6, 9), consisting of large conchoidal fractures, developed to large flat areas, angularity and high topographically positive relief. These features were related to the large amounts of energy available for grinding during glacial action. Once grains entered the littoral system, new textures, predominantly glacio-marine, developed. Commonly these textures consist of large conchoidal fractures, large blocks, arc-like steps, M.V.'s, angular outline and orientated etch pits (see Margolis and Krinsley, 1971), with reference to table 5.xv). This surface texture configuration is generally applicable to the Barrier Island samples. Although the glacial till deposits at Montauk Point are considered the major provenance, analysis of grain morphology has indicated a secondary provenance source, found in both onshore and offshore samples (see Inlet plates 1, 2, Flood Tidal Delta, plates 1, 2, Overwash plates 1, 2). These grains display a characteristic elongate form and is a visual indication of a quartz grain that has undergone strain metamorphisis (Bull, pers. comm.). This type is also apparent in the channel samples (see Channel plate 1 and 2). From this evidence it is tentativly proposed that the Barrier Island sediments are Bi-modal in provenance, with the elongated grains derived from an ancient basement quartz source. It is proposed that future work will investigate this further.

Once in the onshore sink system, homogenization of samples became ubiquitous. No major scale differences were noted between samples although localised differences were evident. Large flat areas were more ubiquitous in the Inlet, Overwash and Dune samples. Sickle pits were found in abundance in the Dune sample (56%). These cresentric mechanical features are found in high energy regimes and may be a surface manifestation of large scale'northeasters' or hurricances. Cracks were also common in both Dune and Beach samples (83% and 76 % respectively). Cracks may be found more commonly in metamorphosed quartz (Bull pers.comm.), another indication that a metamorphic provenance may be a source for the nearshore samples. Multicycle textural development was also evident, confirming earlier work (Williams et al, 1985).

Checklist results generally emphasised large scale similarities between samples, with few features discriminating. Homogenization of glacio-marine sediments reduced effectivness of the checklist to delineate, although certain samples (Dune, Inlet) revealed textures that, although not discriminating, were distinctive and need further work to explain their more complex surface textures. In general, onshore sink processes failed to superimpose any noticable individual textures which could provide discrimination. This was due to energy conditions associated with the onshore processes being similar, therefore producing similar textures. The dune sample does indicate that higher energy levels associated with storms, may produce different surface patterns, although greater work is needed to confirm this.

Statistical analysis is a relatively new approach in S.E.M. analysis (Chapter 4) and little work has been done on its applicability or results in reconstruction studies. The use of binary data, despite reservations (Chapter 5) produced results generally in keeping with the visual and checklist results. Five group analysis was disappointing (see table 5.iii) but two group discrimination produced far superior results (table 5.v). Checklist and visual discrimination between nearshore samples was generally inconclusive but two group analysis produced a relatively high degree of discrimination. This would imply that subtle differences do exist between nearshore samples, with discriminant analysis able to differentiate changes in surface texture combinations that are not so easily distinguished by qualitative methods alone. This is especially true for two group analysis of Beach vs Overwash (table 5.xi), and F.T.D. vs Beach (table 5.viii). In all statistical results large combinations of variables were used, an indication that no single variable was solely discriminating. While it would be premative to suggest that statistical pattern recognition in S.E.M. analysis had been fully explored, the results have been meaningful, in discrimination terms, especially in results between unlike samples (table 5.ii).

In the analysis of the onshore and offshore samples (Appendix A), a generic link is indicated, especially in the proximal grains, with samples to the West and East of Channel H less obviously linked to the onshore samples. Elongated grains, similar to those found in nearshore samples, were prevalent in the proximal samples (see proximal plate 1), but these grains had not undergone such extensive edge abrasion found in nearshore elongated grains (see Inlet plate 1, 2). Fourier analysis revealed two grain shape types (Reister et al 1982) but it is not clear whether a bi-modal provenance for nearshore samples was suggested, as has been forwarded in this work.

Generally the S.E.M. textural results were consistant with those obtained for glacio-marine sediments, from other workers particularly Donahue and Krinsley (1968). Although their work was carried out on a large scale, observations from this study were generally consistant to this earlier work. Nearshore samples have shown themselves to be generally generically similar, with textural components commonly found in several different sink samples, this highlighting the difficulty in discrimination. At the outset it was envisaged that energy levels and therefore processes would be sufficiently dissimilar, to impart unique textures within each sample. This is obviously not the case here, not even for nearshore samples, that have undergone more complex deposition/ transportation processes, e.g. Flood Tidal Delta. Only in the Dune sample is a higher energy level indicated, with the presence of sickle pits (see table 5.ii) and this may be associated with storm energy.

The glacial input, either from Montauk Point or the offshore lobes, when subjected to nearshore processes, has revealed a basic glacio-marine type surface texture. Aeolian features have developed but only as a local response to short term high magnitude energy conditions. Provenance has been shown to be all important in shaping grain texture with nearshore processes only modifying the surface features and not obliterating them totally. A bi-modal provenance is tentatively proposed.

5 (iv) Conclusions

The aim of this study was the environmental discrimination of Barrier Island sediments, by the scanning electron microscope. Several techniques were used (see Chapter 5 (i), (ii), (iii)) and results compared to results obtained by earlier workers particularly Donahue and Krinsley (1968) and Bull (1981).

Discrimination between the five nearshore Barrier Island sediments was only partially successful due to the dynamic nature of the Barrier Island system. The postulation that each of these processes imparted distinctive suites of features this allowing discrimination, has proved to be only partly successful. Homogenization created similar textures in all samples and analysis confirmed the glacio-marine nature of the samples, longshore drift eroded glacial type grains from Montauk Point. These grains demonstrated 'glacial' surface features which subsequently were modified by the resulting fluvial processes. Three phases of superimposition are tentatively proposed (a) Mechanical, (b) Chemical and (c) Mechanical phase.

Statistical analysis, whilst producing some interesting results failed to distinguish between the five group samples, although the two unlike control samples were discriminated. Caution was needed in interpreting these results. Generic linkage was indicated between several sediment types particularly Overwash and Dune samples. From the results obtained (see Chapter 5) discrimination could not be attempted by one method alone.

All the results indicated that generally the Barrier Island sediments textures are glacio-marine in nature, with Dune samples producing little aeolian features. The Barrier Island processes were not, in energy terms, distinctive enough to superimpose unique textures and therefore textures in all five samples were similar. The offshore study (see Appendix A) indicated the presence of offshore grains in the nearshore samples. In both onshore and offshore samples, two grain types were revealed and a bi-modal provenance source is proposed for these samples.

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Appendix (a)

Offshore Lobe Substudy

An important consideration is whether features seen in grains taken from the Barrier Island environments, derived from an earlier sediment cycle or imposed during nearshore processes. Two sediment provenances have been suggested (Taney, 1961), longshore drift from Montauk Point and offshore glacial lobes (see Chapter 2). A critical question is, is it possible to identify similar surface features and morphology in onshore and offshore glacial samples? To this end a small substudy was made as a corollary to the main investigation.

Three samples were investigated, (1) Proximal to Channel H (see Fig.2.7); (2) West of Channel H; and (3) East of Channel H.

Proximal to Channel H

The offshore sample contained both angular spherical grains and the distinctive elongate grains found in the onshore samples (see Plate Edge abrasion in particular and mechanical processes generally were reduced. Large flat areas were again ubiquitous derived from the earlier glacial cycle. It is tentativly concluded that there is a generic connection between Channel samples and a small percentage of onshore grains.

West and East of Channel H

These two samples were obtained from areas adjacent to Channel H (see Fig.2.7) drainage channel.

The samples contained a reduced amount of elongate-type grains and were generally more rounded, with a reduced angular component. Grains with such high sphericity have rarely appeared in offshore samples, emphasing the contribution made by the angular grains, to the offshore samples, from Montauk Point. M.V's were common but edge abrasion, as seen in other samples is reduced. Large flat areas were again extensive. It appeared that the channel sands only provided the elongate grains. The blanket sands to the east and west of the channel may then represent the unglaciated portion, as suggested by Reister et al (1982). The checklist indicated that approximately 20% of the onshore sample contained rounded grains, and it is suggested that the offshore blanket sand has provided a small proportion of this component. The channel and adjacent samples differ markedly in surface texture and morphology.

Proximal to Channel H plates

Plate I

Elongated grain, similar to Inlet Plate I, Dune I and Overwash I. It does not have the same degree of edge abrasion but ubiquitous flat areas are present. Few M.V's or V-shaped notches are present. In the onshore samples, edge abrasion is greater but general axis length is similar.

Plate 2

Angular grain with large flat areas, displaying greater edge abrasion with V-shaped notches and M.V's. Little chemical activity.

Plate 3

Displays large flat areas with little leading edge abrasion.

Plate 4

Angular grain with moderate edge abrasion. M.V's and V-shaped notches are superimposed on the large flat areas.

Plate 5

Irregular grain with blocky topography and moderate edge abrasion, contrasting with the preceeding plates.

Plate 6

Subangular grain (compare with Dune I). Distinctive V-shaped blocky depression, M.V's and notches. Edge abrasion is severe.

Plate 7

Angular grain with large scale grain breakage surface.

Plate 8

Angular grain, with old C.F's and a chemical surface.

Plate 9

Angular grain with severe edge abrasion and M.V's.

Plate 10

Surface breakage area with large flat areas and M.V's on leading edges.

Plate 11

Elongate grain with mild to moderate edge abrasion with old C.F's and M.V's.

Plate 12

'Chemically' altered grain with surface breakage area.

PROXIMAL

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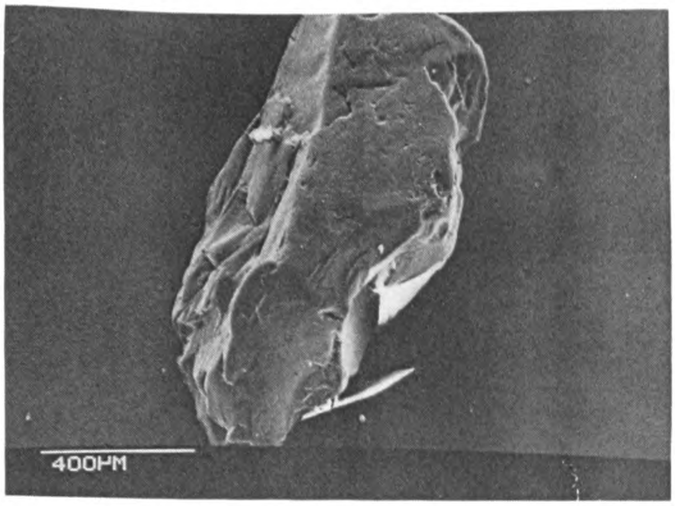

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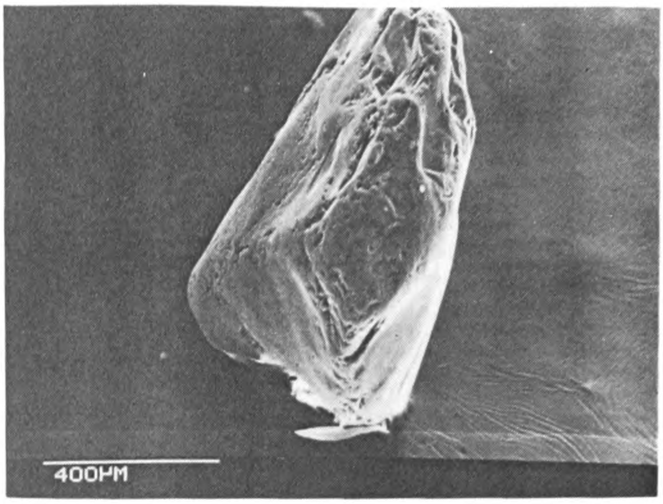

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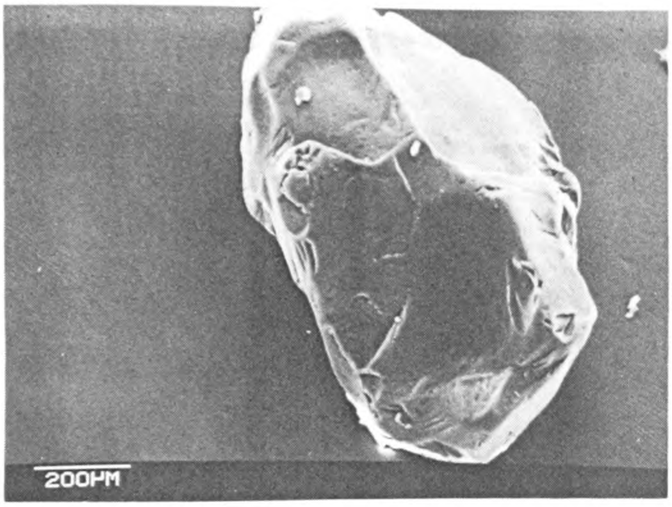

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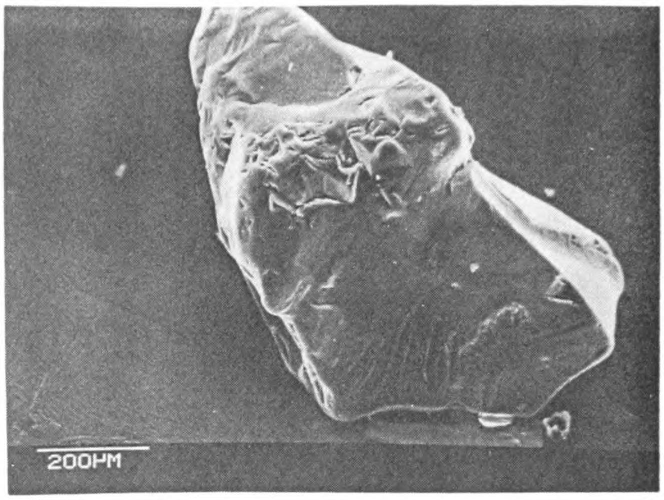

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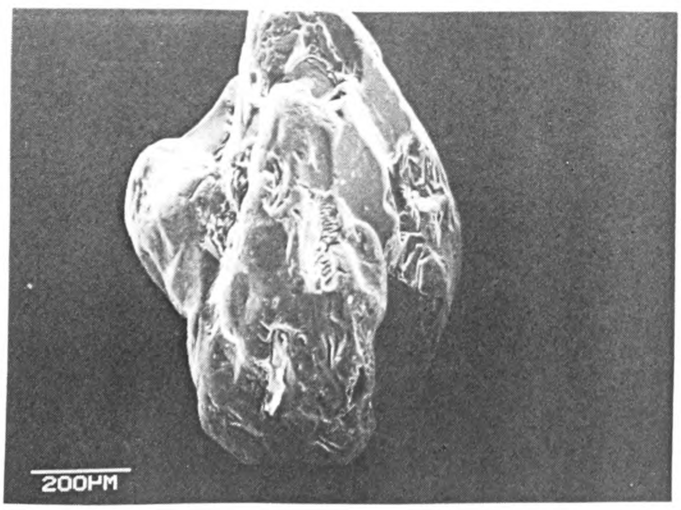

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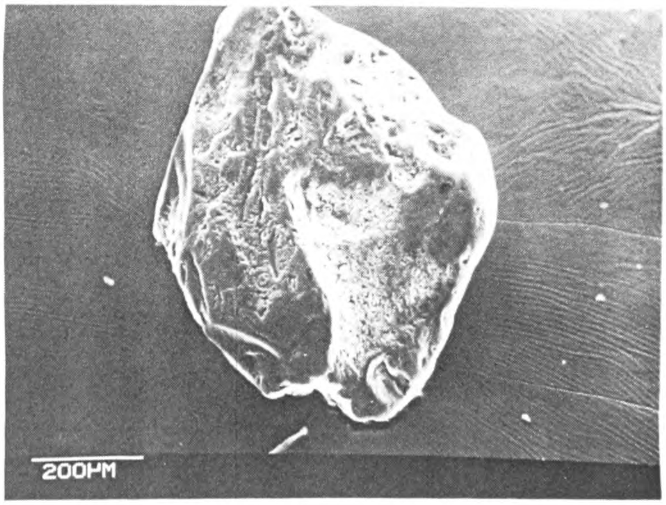

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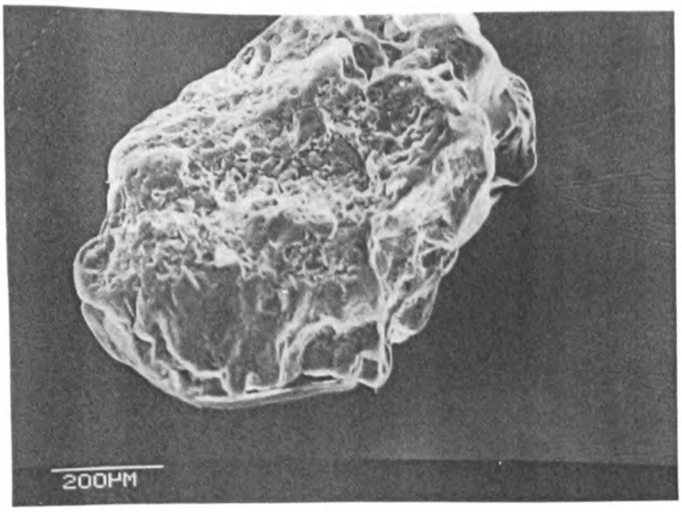

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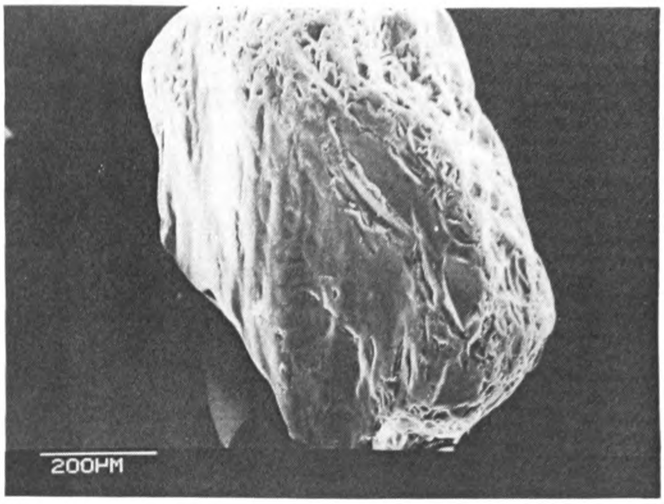

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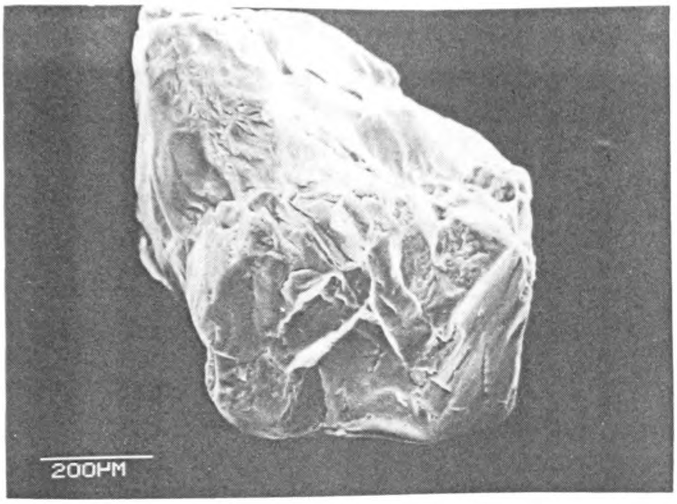

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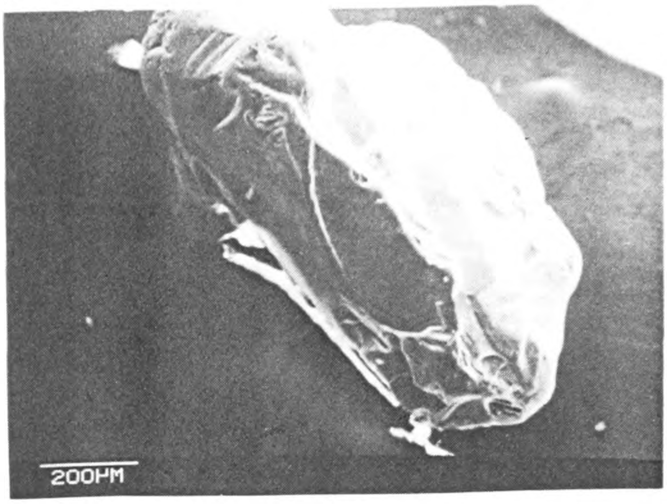

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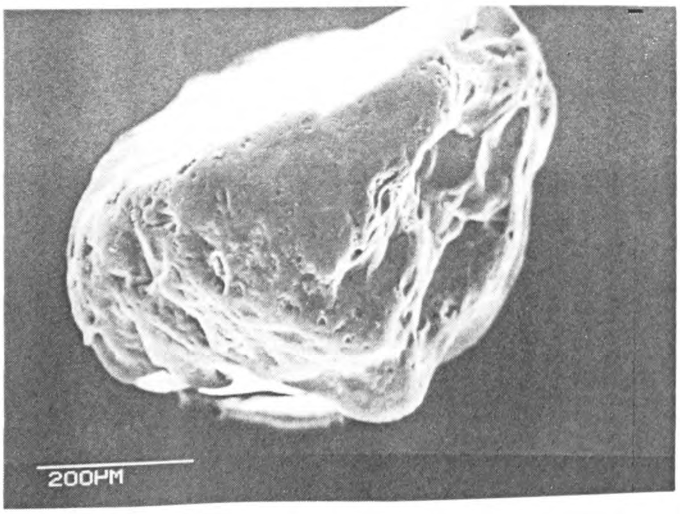

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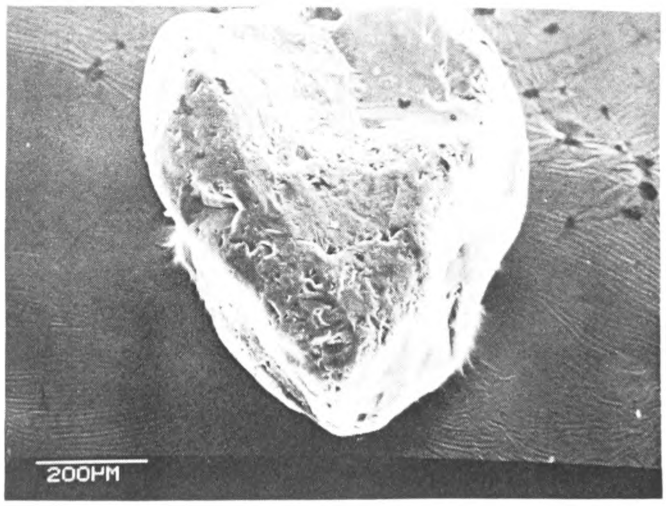


West and East of Channel H plates

Plates 1 - 4

Rounded, high sphericity grains. M.V's, V-shaped notches are extensive coupled with large scale surface breakage zones. Old mechanical surfaces are present, with some large flat areas. Edge abrasion is reduced but water rounding is the dominant process.

Plate 5

Subrounded grain with M.V. damage and larger scale grain breakage.

Plate 6

An angular grain with reduced M.V's. Large flat areas dominate the original mechanical surface.

Plate 7

Subangular grain with blocky topography. M.V's are common, with evidence of grain breakage.

Plate 8

Subrounded grain with surface breakage and large flat areas.

Plate 9

Subangular grain with M.V's and L.F.A's.

Plate 10

Angular grain with L.F.A's. C.F's present but few M.V's are present.

Plate 11

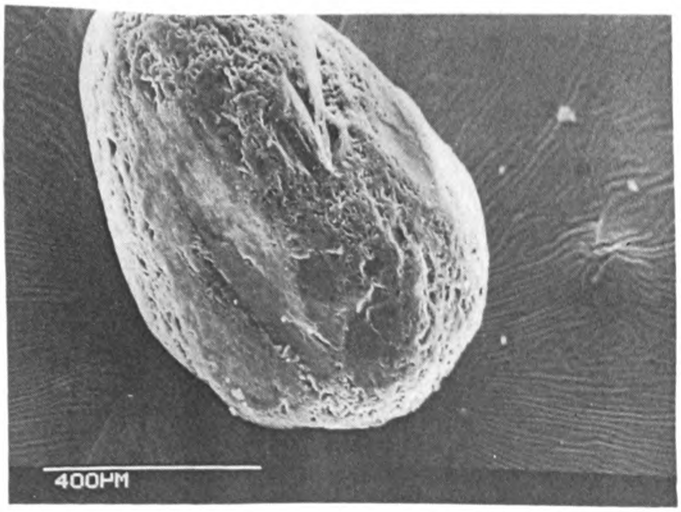
Angular grain with L.F.A's. There are few M.V's or little edge abrasion.

Plate 12

Subrounded with extensive M.V. development and old mechanical surface.

WEST AND EAST OF CHANNEL H

1



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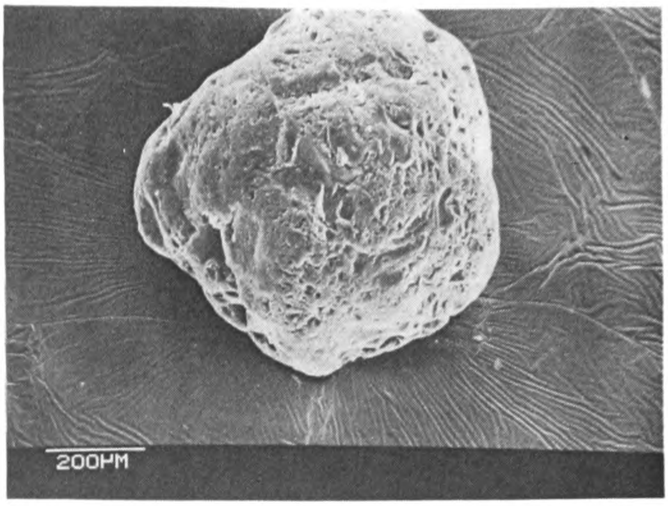

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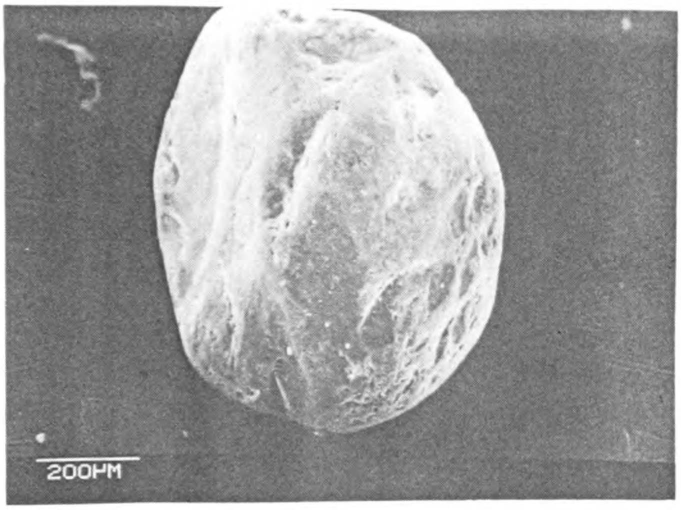

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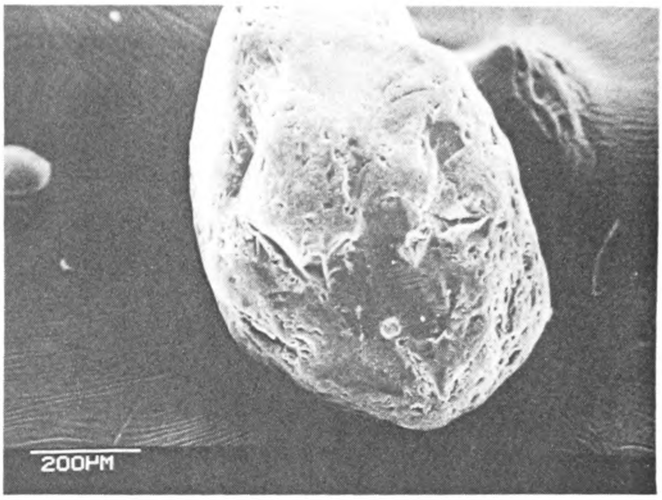

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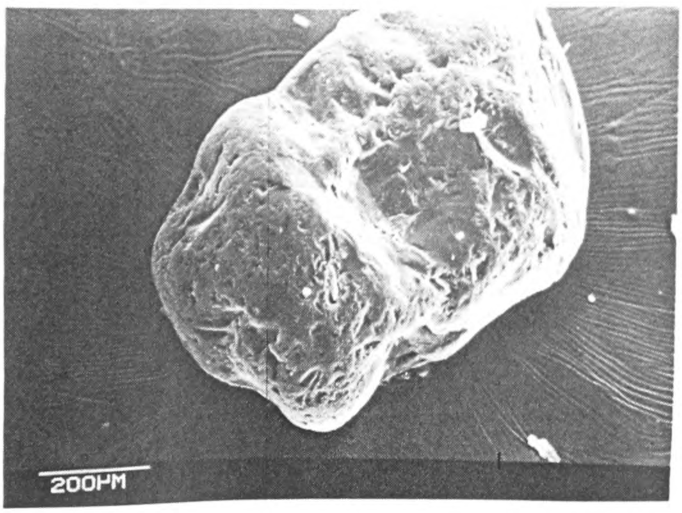

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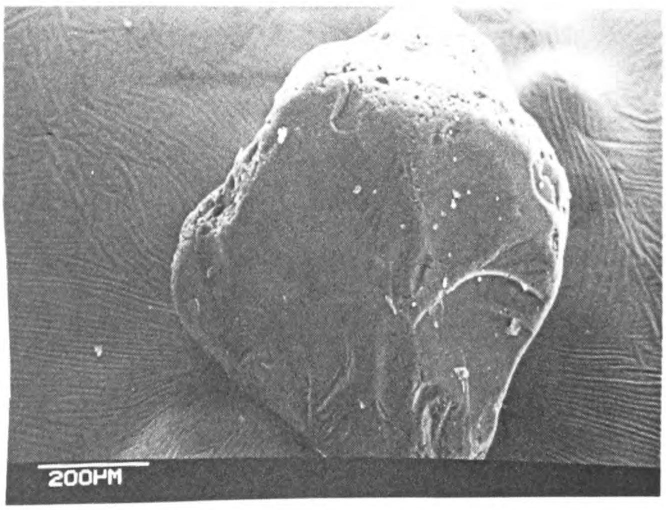

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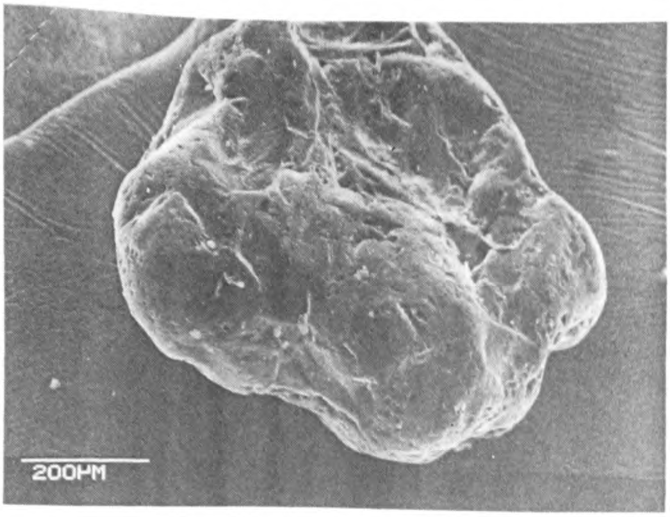

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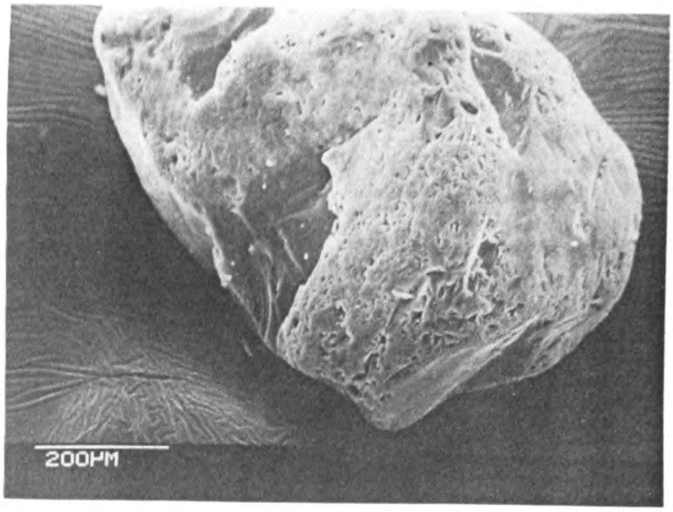

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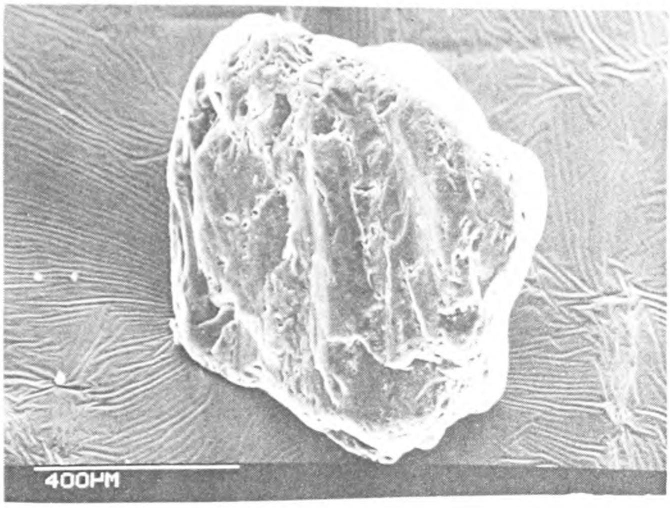

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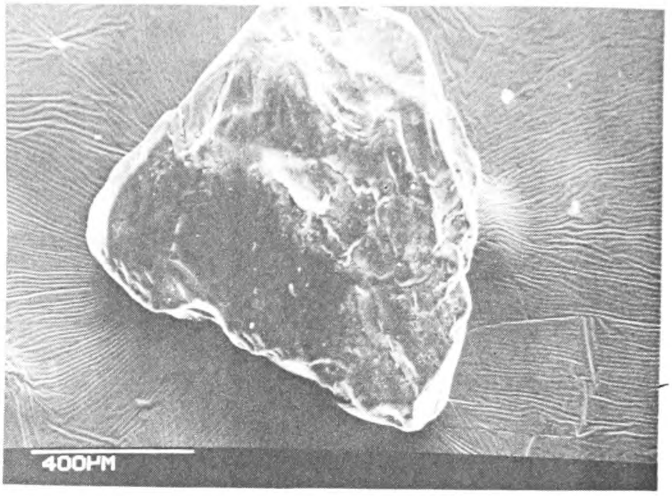

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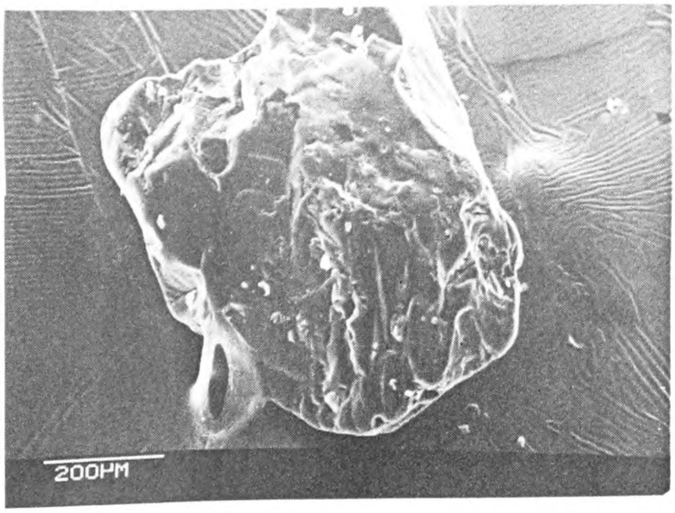

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